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IMPERIAL BUREAU OF ENTOMOLOGY.

# BULLETIN
OF
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VOL. XII. 1921.

## A REVISION OF THE GENUS LEPTOCONOPS, SKUSE.

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### INTRODUCTION.

The genus *Leptoconops* was erected in 1890 by the Australian dipterist Skuse for a minute black Chironomid fly which he captured at Woronora, near Sydney, New South Wales. This genus he placed in the last of the three sections into which he divided the family CHIRONOMIDAE, namely, the CERATOPOGONINA. The fly greatly resembled a small species of *Simulium* in general facies, and presented certain peculiar characters which rendered it strikingly distinct from other members of the section. Indeed, certain authors (Mik 1894, Johannsen 1905) have since drawn attention to the marked similarity in the wing venation of an American species (*L. torrens*, Twns.) and *Corynoneura*, a genus of the subfamily CHIRONOMINAE. Later (1907) Noé suggested the formation of an additional subfamily—LEPTOCONOPINAE—for the Australian and allied species (at that time classified in three genera), and Malloch (1915), although acknowledging that the genus *Tersesthes*, Twns. (a synonym of *Leptoconops*), was unknown to him, associated it with the CHIRONOMINAE rather than with the CERATOPOGONINAE. Apart from the wing venation, however, *Leptoconops* shows no affinities with *Corynoneura*, but rather agrees with the Ceratopogonine midges, particularly in regard to the structure of the thorax and mouth-parts. Several species of *Leptoconops* have now been described, but owing to differences in the interpretation of, or slight variations in, some of the generic characters given by Skuse, as well as to subsequent descriptive errors, they have, in greater part, been referred to the genera *Tersesthes*, Twns., and *Mycterotypus*, Noé. As was to be expected, however, the close agreement exhibited in the diagnoses of these genera and of *Leptoconops* has caused several authors to suggest their identity; but indefinite or partial conclusions* only were reached, since the genotype of *Leptoconops* (*L. stygius*, Sk.) was not re-examined.

Through the courtesy of several gentlemen (individual acknowledgments are made in the text of the systematic portion of this paper) I have been privileged

* Castellani and Chalmers (1913 and 1919) give *Tersesthes* and *Mycterotypus* as synonyms of *Leptoconops*, stating that in so doing they follow Kieffer. The latter author, however, did not definitely reject these names, and in his recent works still refers to them.

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to examine the majority of the known species of this genus, including *L. stygius*, and have thus been able to decide certain questionable morphological characters which were largely responsible for the previous confusion. The new species described herein were received from the Imperial Bureau of Entomology (per Dr. G. A. K. Marshall), the British Museum (per Mr. F. W. Edwards), and the United States National Museum (per Prof. L. O. Howard and Dr. J. M. Aldrich); the types and co-types of these species have been returned to the collections from which they came, as subsequently indicated at the end of the respective descriptions.

## Synonymy and Classification.

Skuse's definition of *Leptoconops* is as follows:—"Antennae in the female 2 + 11-jointed; first joint of scapus large, disciform; second smaller, globose; flagellar joints globose, gradually diminishing in size, more ovate towards the apex, terminal joint elongate-ovate. Proboscis prominent. Palpi four-jointed; first and second joints small, third greatly incrassated, about three times the length of the first or second; fourth not as long as the last, slender, cylindrical. Wings naked. All longitudinal veins taking their origin at the base of the wing. Marginal cross-vein present. Middle cross-vein wanting. Fourth and fifth longitudinal veins only forked."

In 1893 Townsend founded the genus *Tersesthes*, but although acquainted with Skuse's work, would seem not to have appreciated the close resemblance between his genus and *Leptoconops*. Practically the only points of difference between the two genera that can be obtained from his description are that the palpi are composed of three segments and the wings covered with microscopic hairs; but in his figure of the wing the costa is extended to the apex, terminating near the upper branch of the fourth vein.

Noé (1905) erected the genus *Mycterotypus* for two Italian midges. He was, however, doubtful as to its distinctiveness from *Leptoconops* and *Tersesthes*, and was unable to decide whether the differences between these two genera and *Mycterotypus* were real or apparent. But in view of the facts that he could distinguish satisfactorily only three palpal segments, that the venation apparently differed in several particulars, and chiefly that he believed the "cerci" (lamellae) to be absent in *Leptoconops*, he finally resolved to place his species in a separate genus.

Johannsen (1905) concluded that *Leptoconops* and *Tersesthes* were very closely related, if not identical, and that they could only be distinguished by the segmentation of the palpi. Kieffer (1906), however, retained all three of these genera, but subsequently (1908) suggested that they were probably synonymous and that Townsend's figure of the wing showing the extension of the costa to the apex was inaccurate. Langeron (1913), after studying the venation of a Tunisian species and the figures of the wings of *Leptoconops* and *Tersesthes*, considered the former genus and *Mycterotypus* very nearly allied, but expressed surprise that Kieffer should think *Tersesthes* and the latter identical. Lutz (1913) was the first author who actually compared specimens of any of these genera; he examined both of Noé's species of *Mycterotypus* and Townsend's *Tersesthes torrens*, and definitely decided that they were congeneric. De Meijere (1915) briefly discussed the differences which existed, or were said to exist, between the three genera, and concluded by adopting Kieffer's suggestion of identity and listing all the species then known under *Leptoconops*. The latter author, however, does not appear to have reached a definite decision in this regard, for although placing *Tersesthes* and *Mycterotypus* under *Leptoconops*, he yet (1917 and 1918) retains the names to indicate groups of species; moreover, in spite of previous suggestions of inaccuracy, he (1917) still accepts Townsend's interpretation of the wing venation, but employs it for purposes of specific differentiation!

Comparisons of the genotype species of *Leptoconops* (*L. stygius*), *Tersesthes* (*T. torrens*) and *Mycterotypus* (*M. bezzii*) have shown definitely that all are congeneric, and therefore the last two generic names must sink under *Leptoconops*. The value and nature of the various characters upon which the separation of these genera was based will be discussed later in connection with the external morphology.

In a supplement to his 1918 paper Kieffer divided *Leptoconops* into three genera as follows :—

" 1. Antennes de la ♀ composées de 12 articles ; crochets tarsaux simple, égaux, petits ; type : *kerteszi*, Kieff. (Région palearctique).
Genre *Holoconops*, n.g.

Antennes de la ♀ composées de 13 articles 2.

" 2. Crochets tarsaux de la ♀ bifides, les 2 rameaux inégaux (Indes orientales).
Genre *Schizoconops*, n.g.

Crochets tarsaux de la ♀ simple, inégaux au tarse antérieur, égaux au tarse postérieur (Australie). Genre *Leptoconops*, Skuse."

This classification cannot be maintained for two reasons : first, the two types of differential characters used are not of the same value and are neither of them sufficient for purposes of generic separation, and, secondly, the description of the claws of *Leptoconops* (with type *L. stygius*) is erroneous. *Holoconops* may be retained with advantage as a subgenus by reason of the antennal structure of the females, *Leptoconops*, in the restricted sense, being reserved for those species with the full complement of segments. *Leptoconops* (*sens. str.*) can, if necessary, be further separated into two groups on the structure of the claws ; but even if such groups be worthy of subgeneric rank, the name *Schizoconops* cannot be employed, since the genotype of *Mycterotypus* (*M. bezzii* was the first species described by Noé) possesses toothed claws, thus giving the latter name priority.

In 1915 de Meijere described a species (*L. albiventris*) from New Guinea which differed from all other *Leptoconops* in the structure of the ovipositor. The discovery of an African species possessing a similar ovipositor, and the fact that in both species this character is supported by others not present in *Leptoconops*, appear to justify the erection of a new genus ; this is described on p. 24 under the name *Acanthoconops*.

## Distribution.

The members of the genus *Leptoconops* (*sens. lat.*) are widely distributed, but so far as is known are confined to countries lying approximately between the parallels of latitude 40° North and 35° South. Representatives occur in Italy, Sardinia, Asia Minor, Bengal, Siam, Northern, Central and South-West Africa, United States of America, Cuba, Brazil and Australia. The two species of *Acanthoconops* are found in New Guinea and Zanzibar.

## Biology.

Nothing is known of the life-histories or early stages of these flies, and comparatively little concerning the habits of the adults. In fact, the only species which have been studied in any detail are *L. bezzii* and *L. irritans*, both of which were investigated by Noé (1905 and 1907) in the Roman Campagna ; and to a less extent *L. kerteszi* (*Mycterotypus laurae*), observations on which have been recorded by Weiss (1912) and Langeron (1913). Certain authors (Noé, Lutz, and, according to Weiss, Bezzi) have suggested, in view of the greatly developed ovipositor, that the eggs are not deposited superficially, and that the larvae are terrestrial, living among the roots of grasses, etc. Noé, indeed, excluded water as the larval habitat, since he failed to rear either of the Italian species from various aquatic larvae collected during his investigations, even although adults of both flies were present in enormous numbers at the time ; and because both species appeared and subsequently increased greatly in numbers at a period

when water was relatively scarce. Weiss, on the other hand, states that at Tabeditt, South Tunis, *L. kerteszi* and *Simulium maculatum*, Mg. (*S. lineatum*, Fries) occur in common swarms, and show such close association as adults that he believes the immature stages of the two flies will be found near together. In this connection I am indebted to Dr. J. M. Aldrich, of the United States National Museum, for the following interesting observation, which indicates that the larvae of *L. torrens*, at least, are terrestrial in habit. He writes : " Several years ago, before my connection with the Museum, I identified a few specimens as *Tersesthes torrens*. The two females, which I retained in my private collection, have labels reading, 'Maxwell, N.M. Reared from pupae of *Tachina mella*, Webster. No. 11154. C.K.Wildermuth.' The significance of the rearing record is that the adults made their appearance in a breeding cage containing pupae of the fly ; this proves not parasitism, but that the larvae are terrestrial, as is known to be the case in some of the CERATOPOGONINAE."

A perusal of the data subsequently given in the systematic portion of this paper in connection with the habitats of the different species provides some indication of the types of country in which these flies are known to occur, and of the avidity with which they bite. It will be seen that they have been found in what appear to be both relatively dry and well-watered districts, also in low-lying as well as mountainous regions. Noé states that *L. irritans* is especially prevalent in the coastal plains of the Roman Campagna. Langeron records *L. kerteszi* from marshy places in the desert in southern Tunis ; Willcocks (1918) has observed the same insect in the Nile delta ; while Weiss, Townsend (1893) and others have found species at altitudes varying from 1,600 ft. to 7,000 ft. So far as is known, they are diurnal insects, continuing their activities throughout the hottest parts of the day. Noé states that in Italy *L. bezzii* and *L. irritans* (locally known as ' serapiche ') appear towards the end of May, reach their maximum abundance about the middle of June, and then gradually decrease in numbers and disappear early in September. The females of several species are known to bite man and his domestic animals, and to the former at least sometimes cause great annoyance and inconvenience. In some districts they have gained an evil reputation, and indeed at certain seasons would appear to be very serious pests, since at the period of maximum abundance the females of some species attack in dense swarms. According to Noé, *L. irritans* may occur in such swarms that no defence is possible, and he adds that labourers working on the railway from Rome to Pisa were sometimes forced to take shelter in order to escape these massed attacks. *L. kerteszi* is also known to adopt this habit (Weiss), and Sambon (1913) states that Chalmers in the Nile delta " obtained from the fellahin a very definite history of small black, blood-sucking flies appearing in swarms, and Dr. Gough told him that this fly scourge of the delta is undoubtedly *Leptoconops* ; " Chalmers was unable to find *Simulium* in this region, but *L. kerteszi* is abundant in certain localities (Willcocks). Pratt (1907), writing on North American blood-sucking midges, says that Barber considers *Leptoconops* (*Tersesthes*) " much worse as a pest than any *Ceratopogon* (*sens. lat.*) he has ever encountered." The bites are painful and the subsequent local reactions irritating and persistent ; *L. irritans*, in addition, also causes considerable discomfort by crawling about the body, among the hair, beneath the clothes, in the ears, etc. (Noé). Noé's observations, however, tend to indicate that in some respects the habits of different species are not identical ; *L. bezzii* is said to prefer the neighbourhood of houses and outbuildings rather than the open plains, and to be particularly attracted by poultry, in the houses of which the females shelter overnight. Further, although the females apparently prefer blood for food, Noé has seen both sexes of this species on flowers, and remarks that the males are especially fond of *Euonymus*.

### ASSOCIATION WITH DISEASE.

Grassi (1901) endeavoured to obtain the experimental infection of *L. irritans*, Noé, with malaria parasites. He fed twenty-eight " wild " females of this species upon

three patients, two of whom were infected with *Plasmodium falciparum* and one with *Plasmodium falciparum* and *Plasmodium vivax*. No infection of these midges occurred although females of *Anopheles maculipennis* fed at the same time and on the same patients became infected from two of the three cases. Grassi concluded that *Leptoconops* (*Centrotypus*) was not able to transmit human malaria.

In 1913 Sambon extended the possible carriers of pellagra to include, besides the SIMULIIDAE, certain blood-sucking midges; he particularly referred to *Leptoconops* in this connection, basing his chief reason for so doing on Chalmers's observations (see above) made in pellagra districts in Lower Egypt.

Chatton and Blanc (1917) in a paper on *Toxoplasma* and toxoplasmosis of the gundi (*Ctenodactylus gundi*) discuss the natural ectoparasites of this animal; among these they make specific mention of two biting flies, namely *L. kerteszi*, Kieff. (*Mycterotypus laurae*, Weiss), and *Simulium maculatum*, Mg. (*lineatum*, Fries).

## SYSTEMATIC ACCOUNT.

### Genus **Leptoconops**, Skuse (*sens. lat.*).

*Leptoconops*, Skuse, Proc. Linn. Soc. N.S.W. (2) iv, p. 288 (1890).

*Tersesthes*, Twns., Psyche, vi, p. 369 (1893).

*Centrotypus*, Grassi (*nomen nudum*), "Die Malaria: Studien eines Zoologen," Jena, p. 118 (1901).

*Mycterotypus*, Noé, Atti Accad. Lincei, Ser. 5, Rendiconti, xiv, p. 114 (1905); Arch. Zool. Napoli, iii, p. 101 (1907).

*Mycteromyia*, Lutz (*nec* Phil.), Mem. Inst. Osw. Cruz, iv, p. 24 (1912); ibid. v, p. 69 (1913).

*Holoconops*, Kieff., Ann. Mus. Nat. Hung., xvi, p. 135 (1918).

*Schizoconops*, Kieff., Ann. Mus. Nat. Hung., xvi, p. 135 (1918).

The external morphology of the adults of this genus has been discussed in detail by Townsend (1893), Noé (1905 and 1907), and Langeron (1913) in relation to the species described by them. Owing probably to lack of material, however, no general account based on the examination of a number of species has yet been given, and it is therefore thought advisable—especially in view of the discrepancies which have appeared—to include here a description of the more important structures.

Fig. 1. Head of: (*a*) *Acanthoconops spinosifrons*, sp. n., ♀; (*b*) *Leptoconops kerteszi* var. *americanus*, n. (× 90 circa).

*Head.* Eyes bare, widely separate (the space between them varying from one-fifth to almost one-half the width of the head) in both sexes.* Vertex and occiput bearing a few short hairs or bristles ; frons nude or with at most a single pair of short bristles between the eyes (fig. 1, *b*). Clypeus moderately pronounced, rounded, hairy.

*Proboscis* as long as, or rather less in length than, the height of the head. Mouth-parts in the female as follows : labium soft and hairy, broad, the labella relatively large ; labrum strongly chitinised, broad at the base, gradually tapering towards a rounded apex, the extremity armed with three recurved teeth ; hypopharynx less strongly chitinised than, but somewhat similar in shape to, the labrum, the apex devoid of teeth, pointed and scoop-like ; mandibles and maxillae† well-developed, the former moderately chitinised, relatively broad and obliquely truncate or curved distally, bearing twelve to twenty-four small, closely apposed teeth, the maxillae narrower, slightly shorter and more pointed, armed with from twelve to thirty larger and more widely separated teeth. Mouth-parts in the male less strongly chitinised than those of the female ; extremity of the labrum hairy, mandibles not visible (? absent) in the single specimen available, maxillae slender, thinly chitinised, pointed, without teeth.

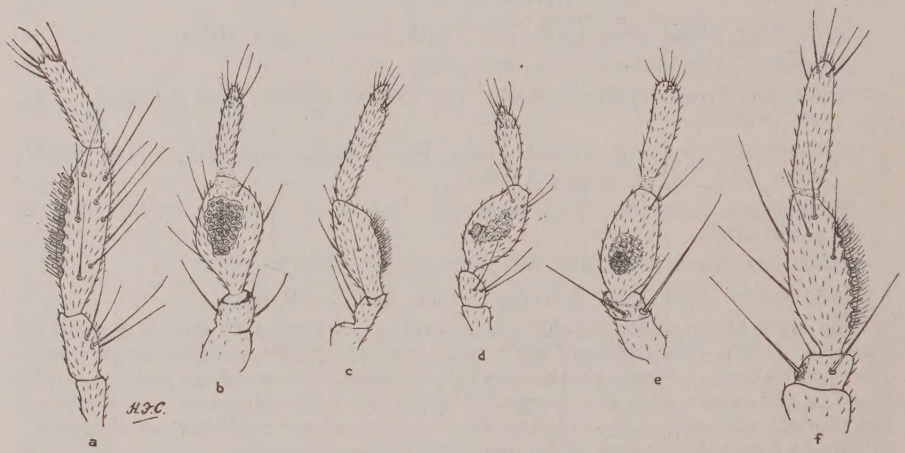


Fig. 2. Palpi of ♀ ♀ of : (*a*) *L. stygius*, Sk. ; (*b*) *L. torrens*, Twns. ; (*c*) *L. rhodesiensis*, sp. n. ; (*d*) *L. kerteszi* var. *americanus*, n. ; (*e*) *A. spinosifrons*, sp. n. ; (*f*) *L. siamensis*, sp. n. (× 220 circa).

*Palpi* (fig. 2) composed of four segments. In the female the first and second segments are reduced in size and often indistinctly separated one from another, the third incrassate, the last relatively large, representing the combined small fourth and fifth segments of other CERATOPOGONINAE ; the sensory pit of the third segment is highly developed, the orifice often large, occupying the greater portion of the inner aspect, or occasionally small, sub-circular ; terminal segment with an apical whorl of hairs. In the male the palpi are longer than in the female, and the third segment is not, or scarcely, swollen.

* In this account remarks concerning male characters are based upon the examination of a specimen provisionally referred to *L. torrens* (see p. 15) and Noé's description of *L. bezzii*. The male of *L. kerteszi* (*M. laurae*, Weiss) is not considered here, since, as shown on p. 22, its structure in certain respects is so peculiar that confirmation of Weiss's observations is desirable before any definite statements can be made.

† Langeron (1913) in his description and figure of the mouth-parts of the female of *L. kerteszi* var. *peneti* (*M. laurae* var. *peneti*) has, through incorrect interpretation, transposed the names of these structures.

The confusion which has arisen in regard to the segmentation of the palpi has been entirely due to the somewhat rudimentary nature of the first and second segments, and to the varying degrees of differentiation exhibited by them in certain species. The palpi have thus been described as possessing four, three, or even two segments when the basal ones were overlooked or ignored.

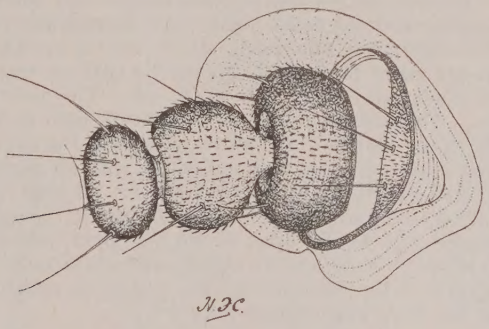

Fig. 3. Proximal portion of antenna of *Acanthoconops albiventris*, Meij., ♀, showing the reduced first segment ; side view (× 510 circa).

*Antennae* set in large subcircular, pale-coloured, thinly chitinised, depressed areas. In the female the antennae (fig. 5, *a–h*, and *cf.* fig. 1) are pilose, composed of thirteen (subgen. *Holoconops*) or fourteen (*Leptoconops, sens. str.*) segments ; first segment (*cf.* fig. 3) (ignored by all previous authors except Lutz) cup-like, broad at the apex, where there is a rim of thickened chitin, narrowing rapidly to a conical base ; second segment large and rounded, the inter-segmental membrane connecting it to the chitinised rim of the first, extensive ; segments of the flagellum eleven or twelve in number, all but the last with a distinct whorl of hairs and two or more transparent spines ; third segment (first of the flagellum) relatively large, pyriform ; terminal segment elongate-oval, considerably longer than any of the others ; intermediate segments (4 to 12 or 13) almost uniform in shape and size, often transversely oval or subspherical, rarely narrowly oval. In the male the antennae are longer and plumose, composed of fifteen segments ; the two basal segments similar to those of the female but larger, the second very large ; segments of the flagellum as shown in fig. 4, *h*, and described on pp. 16 and 17.

*Thorax* arched anteriorly but not projecting over the head, with short and somewhat sparsely arranged hairs on the dorsal surface. Situated laterally, near the anterior margin, and centrally, in front of the scutellum, are small depressions somewhat similar to those found in *Culicoides ;* in each anterior depression, however, are two or three separate oval or rounded, seemingly membranous, areas (which frequently appear as small shining black spots in dry specimens), not a single slit-like area as in *Culicoides*. Scutellum with the posterior margin gently rounded, slightly produced laterally, bearing two or three pairs of strong, and sometimes a few pairs of smaller, bristles. Post-scutellum strongly arched, nude.

*Wings* white, iridescent, with the surface entirely covered with minute upright setae and with a fringe of longer hairs on the distal and posterior margins. The venation (fig. 7) is characteristic, but the veins, particularly the anterior ones, are ill-defined and difficult to distinguish. They can best be followed in dry specimens, but careful manipulation is necessary, as the detection of certain details depends largely on the angle of view and the illumination ; in mounted specimens (unless stained) the venation cannot be observed. The costa is short and, in the female, usually terminates

well before the middle of the wing. The sub-costa is chitinised and more clearly defined than any other vein ; it is closely apposed to the first longitudinal vein, and owing to the folding of the wing surface in this region, frequently obscures, or partly obscures, the base of the latter. The first and third longitudinal veins (the second is absent) are separate basally, but fuse distally, forming with the extremity of the costa a large, slightly raised, yellowish or pale brown area. These two veins are approximated throughout the greater portion of their course, but diverge slightly before fusing with one another and the costa ; this approximation is usually greatest immediately before the divergence mentioned above, and in several species is so close that amalgamation has taken place, with the results that an apparent cross-vein has been formed and a small cell isolated (*cf.* fig. 8, *a-l*). The anterior or radio-medial cross-vein is absent. The general course of the fourth, fifth and sixth veins shows little variation ; the upper branch of the fourth vein joins the apex of the wing below the middle, the lower branch is often very indistinct, with an apparently considerable portion of its base, and sometimes its apex, obsolete. At least three vein-like folds (indicated in fig. 7 by dotted lines) are present, and of these the most anterior—which is evidently homologous with the fold just above the upper branch of the fourth vein in other CERATOPOGONINAE—is relatively strong and conspicuous ; it is, indeed, as strongly marked as any of the veins except the sub-costa, and by most authors has been interpreted as the third longitudinal vein.

Fig. 4. *L.* (?) *torrens*, Twns., ♂ : *a*, clasper ; *b*, claws of front leg ; *h*, antenna (flagellum).
*L. kerteszi* var. *americanus*, n., : *c*, claws of hind leg (near claw foreshortened).
*L. bezzii*, Noé, ♀ : *d*, claws of middle leg.
*L. stygius*, Sk., ♀ : *e*, claws of front leg (ventral view empodium omitted).
*L. siamensis*, sp. n., ♀ : *f*, one claw of front leg.
*L. brasiliensis*, Lutz, ♀ : *g*, first tarsal segment of front leg.
(*a* × 770 ; *b*, *c*, *f* × 490 ; *d* × 220 ; *e* × 450 ; *g* × 260 ; *h* × 90.)

As will be gathered from a perusal of the subsequent specific descriptions and from the illustrations referred to above, this account of the wing venation is based upon the study of the wings of females of several species. Among these are included most of the forms previously referred to *Tersesthes* and *Mycterotypus*, and it therefore follows that the venation in these insects is in no way peculiar, and that venational characters which have been advanced for the retention or differentiation of these genera are either of little value or are the results of incorrect observations.

*Legs* moderately long, the hind pair longest, clothed with short hairs. Femora unarmed. Tibiae each armed distally with a short, stout, ventral spur, those of the fore and hind legs in addition with one or two oblique rows of bristles. First tarsal segment of the fore and middle legs about twice the length of the second, of the hind legs about one and one-half times the length of the second; second to fourth tarsal segments cylindrical, decreasing in length progressively, the fifth segment distinctly longer (in *L. lacteipennis* Kieffer states that it is shorter) than the fourth. Differentiation of the apical bristles of the first and second tarsal

Fig. 5. Terminal segments of antennae of females of: (*a*) *L. siamensis*, sp. n.; (*b*) *L. stygius*, Sk.; (*c*) *L. grandis*, sp. n.; (*d*) *L. longicornis*, sp. n.; (*e*) *L. rhodesiensis*, sp. n.; (*f*) *Acanthoconops spinosifrons*, sp. n.; (*g*) *L. herteszi* var. *americanus*, n.; (*h*) *L. torrens*, Twns. (× 260 circa).

segments into spines has taken place in most species, and of some of the ventral bristles of the first segment (fig. 4, *g*) in a few species. In the latter case considerable prominence has been given to this character by some writers in their specific descriptions, and the exact number and arrangement of such spines has been recorded; but variation in details is frequent, and may occur not only in

different individuals of the same species, but on different legs of the same individual (*cf.* footnote p. 20). Claws equal, small, less than one-half the length of the fifth segment ; in the female similar on all the legs, either simple, each with a bristle arising from the base (fig. 4, *c* and *e*) or dentate, with a strong basal tooth (fig. 4, *d* and *f*) ; in the male (fig. 4, *b*) dissimilar on the fore and middle legs, one simple, the other with a long basal tooth (in *L. bezzii* both are said to be dentate), on the hind legs similar, simple. Empodium in the form of a minute branched bristle.

*Abdomen* of the female composed of nine segments—the ninth greatly reduced in size—clothed with short hairs, and bearing distally two exceedingly long, narrowly conical lamellae (fig. 6). Genital orifice, anteriorly, with a semi-circular chitinous border from which arise numerous small and a few long hairs, the latter directed inwards and backwards over the aperture. Spermathecae usually two in number (occasionally, e.g., *L. kerteszi*, a small third spermatheca is present), subspherical or oval and but slightly produced posteriorly before the junction with the duct. Abdomen of the male more slender than that of the female, the hypopygium conspicuous.

## Subgenus **Leptoconops** (Skuse), Carter.

As here restricted, this subgenus includes only those species in which the antennae of the female are composed of fourteen segments ; in this sex the species fall into two groups according to the claws being simple or dentate.

### **Leptoconops stygius,** Skuse.

*Leptoconops stygius*, Skuse, Proc. Linn. Soc. New South Wales, (2) iv, p. 288 (1890).

*Leptoconops skusii*, Noé (error in explanation of Plate v), Arch. Zool. Napoli, iii (1907).

Skuse's description of this species, the type of the genus *Leptoconops*, is as follows:—

" ♀.—Length of antennae, 0·42 mm. ; expanse of wings, 1·27 mm. ; size of body, 1·66 mm. Entirely black. Joints of antennae with dense light-greyish verticils. Head and thorax levigate, with minute black hairs. Abdomen about twice the length of the thorax, opaque, with some minute black hairs ; lamellae very long, slender. Legs slender. Hind metatarsus one-third longer than the second tarsal joint. In the fore legs, the tibiae rather more than twice the length of the metatarsus. Wings hyaline, rather weakly iridescent ; costal and first two longitudinal veins greyish-brownish, the rest pale and indistinct. Auxiliary vein not distinguishable, apparently wanting ; first and second [*i.e.*, third] longitudinal veins reaching costa before the middle of the anterior border, confluent at the tips, tip of second longitudinal vein almost opposite but immediately beyond the tip of the posterior branch of the fifth longitudinal vein ; marginal cross-vein indistinct ; marginal cell small ; third longitudinal vein [*i.e.*, the strong fold situated in the upper portion of the wing] arcuated, not quite reaching the margin, terminating a little above the apex of the wing ; fourth longitudinal vein bellied downwards at the middle, reaching the margin a little below the apex of the wing, the posterior branch detached ; fork of fifth longitudinal vein wide, the anterior branch twice the length of the posterior.

" *Habitat.* Woronora (Skuse). October."

Through the kindness of Professor S. J. Johnston, of Sydney University, I have been able to examine one of the three specimens of *L. stygius* contained in the Macleay Museum, Sydney, and am thus in a position to supplement the above description with some important morphological details.

♀.—Length of body (specimen mounted in balsam), 2·5 mm. ; length of wing, 1·3 mm. ; length of antenna, 0·48 mm. ; width of head, 0·40 mm.

*Head.* Eyes relatively narrowly separated, the space between them almost one-fifth the greatest width of the head ; clypeus with two pairs of short hairs. Third palpal segment (fig. 2, *a*) relatively not very strongly swollen, elongate, the orifice of the sensory pore extending over the greater portion of the inner side ; fourth segment subcylindrical, about two-thirds the length of the third. *Antennae* (fig. 5, *b*) : fourth to thirteenth segments spherical, with the hairs arranged in oblique whorls, and the spines unequal in size and asymmetrically arranged ; terminal segment short, approximately one and two-thirds as long as broad. *Wings* with anterior veins as shown in fig. 8, *a*.* *Legs :* first and second tarsal segments without differentiated spines, except distally. Claws (fig. 4, *c*) simple and equal, each with a bristle arising from the base. Lamellae bluntly rounded distally, 0·22 the length of the wing. Spermathecae two, heavily chitinised, subspherical (diameter 30$\mu$) ; the commencement of the duct chitinised for a short distance.

**Leptoconops longicornis,** sp. nov.

♀.—Length of body (two specimens), 3·5 mm. ; length of wing, 2·2 mm. ; length of antennae, 0·84 mm. ; width of head, 0·44 mm.

*Head* black,† the antennal depressions pale brown, sparsely clothed with short hairs on the occiput and vertex ; clypeus blackish, with three pairs of dark brown hairs ; eyes not very widely separated, the space between them being approximately one-fifth the width of the head ; frons with a pair of short hairs situated, one on each side, near the lower margins of the eyes. Proboscis blackish brown. Palpi blackish brown, with dark hairs ; third segment elongate, relatively slightly swollen, the orifice of the sensory pit large, occupying the distal two-thirds of the inner side ; fourth segment subcylindrical, stout and short, not more than two-thirds the length of the third. *Antennae* (fig. 5, *d*) long, dark brown, bearing short brown hairs, and long, slightly curved, clear, pointed spines ; fourth to thirteenth segments subspherical to narrowly oval, from 1·0 to 2·1 as long as broad ; fourteenth segment approximately six and one-half times as long as broad, equal in length to the three preceding segments together. *Thorax* shining black (from indications still existing in the dried specimens the scutum was probably dark grey pollinose originally), sparsely clothed with short dark hairs ; scutellum normally with three pairs of stout black bristles ; pleurae and pectus shining black. *Wings* white, iridescent, the fusion of the extremities of the anterior veins forming an elongate brown spot near the middle of the upper margin ; anterior veins as shown (fig. 8, *b*), the distal interspace clearly defined, fifth vein bifurcating appreciably before the extremity of the costa. Halteres greyish buff, the stems somewhat infuscated. *Legs* uniformly dark brown, clothed with dark hairs ; tarsi without distinct spines (except perhaps a distal pair on the metatarsi), but with some of the ventral bristles on the first and second segments stout and spine-like. Claws, equal and simple, similar to those of *L. stygius*. *Abdomen* dark brown, with short dark hairs. Lamellae (fig. 6) paler brown, 0·18 the length of the wing. Spermathecae two, heavily chitinised, subspherical (diameter 50$\mu$) ; the origin of the duct only chitinised.

* I have been totally unable to distinguish the small " vein " (termed by Skuse the " marginal cross-vein ") connecting the distal portions of the first and third veins. The first vein, however, bends sharply upwards just before its termination and at the angle is distinctly swollen, causing the lower edge of the vein to approach more closely that portion of the third vein immediately below it ; at first sight, therefore, the first and third veins appear to be connected at this point and to enclose a minute distal interspace.

† The colours given in the descriptions of this and the following species are as observed in specimens which had been dried after preservation in formalin.

*Habitat.* Interior of Western Australia: (*J. W. Dakin*), 1915. Five females (two cotypes) in the British Museum Collection.

Professor Dakin states that these midges do not trouble one before 10 a.m., and that they disappear at dusk; in between these hours they bite furiously, and the bite irritates for days afterwards.

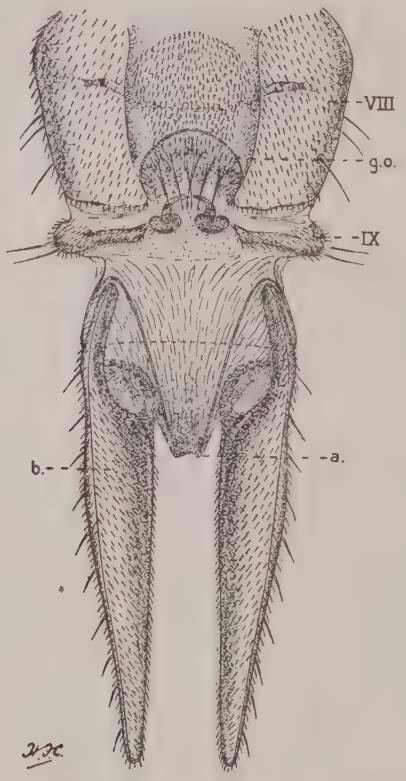


Fig. 6. *Leptoconops longicornis*, sp. n., ventral view of extremity of abdomen of ♀; *g.o.*, genital orifice; viii, sternite of eighth segment; ix, sternite of ninth segment; *a*, anus; *b*, lamellae; (× 180 circa).

**Leptoconops grandis,** sp. nov.

♀.—Length of body (one specimen), 3·5 mm.; length of wing, 2·0 mm.; length of antennae, 0·62 mm.; width of head, 0·44 mm.

Two females of this species, captured at the same place and time and bearing the same data attached to the label as the specimens of *L. longicornis*, were included in the material collected by Professor Dakin. Indeed the two forms were contained in the same tube and, except in antennal structure and certain details of minor importance, resemble one another so closely that, in the absence of males, it is difficult

to know exactly what value to place upon the differences observed. The antennal structure, however, differs so strikingly that I believe specific separation to be warranted; especially since no tendency to intermediate characters occurred in the small series of specimens obtained, and no obvious variation has been seen in the antennal structure of species of which numerous examples have been examined.

The antennae (fig. 5, *c*) are very distinctly shorter than in the preceding species, and the intermediate segments of the flagellum (4 to 13) are subspherical, being from 1·0 to 1·1 times as long as broad; the terminal segment is almost three and one-half times as long as broad, and is equal in length to the preceding two and one-half segments together. Minor differences appear to exist in regard to the venation (*cf.* fig. 8, *b* and *c*), and the dark grey pollinosity of the head and thorax; but, as indicated above, the appearance of the latter may be that normally found in *L. longicornis*.

The two females (cotypes) of this species are in the British Museum Collection.

The three Australian representatives of *Leptoconops* (*L. stygius*, *L. longicornis* and *L. grandis*) at present known are closely related, and as a group are characterised by the relatively narrow space separating the eyes, the structure of the palpi (*i.e.* in regard to the relative lengths of the third and fourth segments), and the absence of spines on the first and second tarsal segments.

**Leptoconops braziliensis,** Lutz.

*Terseslhes braziliensis*, Lutz, Mem. Inst. Oswaldo Cruz, v, p. 66 (1913).

The description of this species given below is drawn up from that published by Dr. Lutz, and from microscopical preparations kindly lent me by him.

♀.—Length of body (two specimens), 1·5 mm.; length of wing, 0·8 mm.; length of antennae, 0·32 mm.; width of head, 0·23 mm.

*Head* dark brown; clypeus with a few short, dark hairs. Proboscis and palpi dark brown; the latter with the third segment moderately swollen and the orifice of the sensory pit large and oval, the fourth segment subcylindrical, almost equal in length to the third. *Antennae* dark brown, with dark hairs and short, slightly curved, clear spines; fourth to thirteenth segments transversely oval, from 0·6 to 0·8 as long as broad; thirteenth segment somewhat pointed distally, two and one-half times as long as broad, almost equal in length to the preceding four segments together. *Thorax* dark brown, clothed with short hairs; pleurae and pectus rather paler in colour than the dorsum. *Wings* white, the basal part of the costa waxen yellow-brown, the costa extending to the middle of the anterior border; anterior veins arranged as in fig. 8, *g*, the fifth vein bifurcating before the extremities of the third vein and costa. Halteres with pale knobs and brown stems. *Legs* brown, the tarsi paler; metatarsi of the four anterior legs (fig. 4, *g*) with several pairs of distinct spines, of the hind legs with short stout bristles, but with spines only at the apex (distal pair); second tarsal segments of all the legs with a pair of spines at the apex. Claws simple and equal, each with a bristle arising from the base. *Abdomen* dark brown dorsally, the fore and hind margins of the tergites narrowly paler; venter pale brown. Lamellae waxen brown, darker at the extreme base, relatively long, 0·33 the length of the wing. Spermathecae two, strongly chitinised, oval ($33\mu \times 24\mu$).

*Habitat.* Brazil: lower reaches of the Rio Tocantin.

According to Lutz this species sucks blood and often attacks man. It may be readily distinguished from other species of *Leptoconops* (*sens. str.*) which possess simple claws by the unusually long lamellae.

**Leptoconops irritans,** Noé.

*Mycterotypus irritans,* Noé, Atti R. Accad. Lincei, Ser. 5, Rendiconti xiv, p. 118 (1905); Arch. Zool. Napoli, iii p. 138 (1907).

*Centrotypus irritans,* Grassi (*nomen nudum*), "Die Malaria: Studien eines Zoologen," Jena, pp. 118-122 (1901).

This species occurs with *L. bezzii* (see page 17) in the Roman Campagna, where, according to Noé, it is very abundant from June to the end of July, and may be found in diminished numbers late in August. The female only is known, and in this sex the species may readily be distinguished from *L. bezzii* by its general facies. Noé confined himself to a comparative description, and gave the following principal differences between it and the latter species.

Size smaller (length, 1·5 mm.; spread of wings, 2 mm.); proboscis and palpi relatively longer, the former more slender, cylindrical; antennal hairs sparser and more spinose; claws simple, the large basal tooth replaced by a robust bristle; abdomen white, becoming isabella-coloured dorsally.

To these I am able to add further details of specific importance, obtained from Sardinian specimens sent me by Professor M. Bezzi.

♀.—Length of body (one specimen), 1·7 mm.; length of wing, 1·1 mm.; length of antenna, 0·53 mm.; width of head, 0·30 mm.

Eyes separated by about one-third the width of the head. Antennal segments 4 to 12 transversely oval to spherical, the length from 0·7 to 1·0 the width; terminal segment about two and one-third times as long as wide, slightly longer than the two preceding segments together. Scutellum with two pairs of bristles. Metatarsi of the fore and middle legs with a few small but distinct spines ventrally, of the hind legs with short, stout bristles, intermixed with which may be one or two spines. Lamellae approximately one-fifth the length of the wing. Spermathecae two (in the single preparation examined a third, very small, oval spermatheca was also present), highly chitinised, oval, relatively large ($64\mu \times 36\mu$), the commencement of the duct chitinised for a very short distance.

Noé's figure of the female palpi shows an exceptionally long, slender terminal segment. This segment, if the drawing is accurate, is considerably longer than the third (the ratio being 1·2 : 1)—a condition which does not occur in any other species. Unfortunately in the specimens at my disposal the palpi are absent or so damaged or arranged that details cannot be observed.

*Habitat.* Italy: Roman Campagna; Sardinia, Cagliari. According to Weiss, Bezzi believes that both *L. irritans* and *L. bezzii* are widely distributed in Northern Italy.

**Leptoconops rhodesiensis,** sp. nov.

♀.—Length of body, 2·5 mm.; length of wing, 1·2 mm.; length of antenna, 0·4 mm.; width of head, 0·33 mm.

*Head* shining black, clothed with short, blackish hairs on the vertex and occiput; clypeus dark brown, with several (about twelve) dark-coloured hairs; eyes rather widely separated, the space between them about one-third the greatest width of the head. Proboscis dark brown or black. Palpi (fig. 2, *c*) dark brown, with dark hairs; third and fourth segments elongate, the third much swollen, with the orifice of the sensory pit moderately large, subcircular, and almost centrally situated, the fourth slightly longer than the third. *Antennae* (fig. 5, *e*) dark brown, with short paler brown hairs and relatively stout blunt spines; segments 4 to 13 transversely oval to subspherical, the length being from 0·6 to 0·9 times the breadth; fourteenth segment ovate, as long as the two preceding segments together. *Thorax* shining black, clothed

with short black hairs ; scutellum and postscutellum similarly coloured, the scutellum with three pairs of black bristles ; pleurae and pectus shining black. *Wings* (fig. 7) whitish, strongly iridescent ; first and third veins joining the anterior margin near the proximal third, point of bifurcation of the fifth vein situated considerably beyond the extremities of the costa and third veins. Halteres whitish, opalescent. *Legs* : femora and tibiae dark brown, with pale hairs, metatarsi and second tarsal segments without conspicuous spines, except distally, where differentiation (into spines or stout

Fig. 7. Wing of *Leptoconops rhodesiensis*, sp. n., ♀ (× 75 circa).

spine-like bristles) of the apical pair of bristles often takes place. Claws equal, simple, each with a short bristle arising from the base. *Abdomen* : dorsum sepia-coloured (shining when held in certain positions), the apical margins of the tergites narrowly paler brown ; venter sepia-coloured medially, paler brown laterally ; both surfaces with short dark hairs. Lamellae dusky white or light grey, 0·2 times as long as the wing. Spermathecae strongly chitinised, apparently elongate-oval (collapsed in the single specimen available) ; the commencement of the duct chitinised for a very short distance.

*Habitat.* North-Western Rhodesia : Kafue Flats, 3,000 ft., 19.x.1913 (*R. C. Wood*), " Biting myself " ; 1 ♀ (type) in the collection of the Imperial Bureau of Entomology.

This species should be recognised without difficulty by the wing venation, the short extent of the anterior veins being a conspicuous character. From *L.* (*Holoconops*) *interruptus*, End., the only other species yet described from South Africa, it may, of course, be immediately separated by the structure of the antennae. The coloration of the abdomen given above must be regarded with reserve, since the specimen was caught when biting and probably contained undigested blood.

**Leptoconops torrens,** Twns.

*Tersesthes torrens*, Twns., Psyche, vi, pp. 369-371 (1893).

This species, the type of the genus *Tersesthes*, Twns., belongs to the group of species in which the claws are simple. I am indebted to Professor L. O. Howard and Dr. J. M. Aldrich for the opportunity of examining female specimens from the Organ Mountains, New Mexico, and a microscopical preparation of a male from Las Vegas Hot Springs, New Mexico. The females were collected by Townsend on horses, and agree in all essentials with his description ; the males, however, cannot at present be more than provisionally associated with this species, but in view of Weiss's description of the male antennae of *L.* (*Holoconops*) *kerteszi* (*M. laurae*, Weiss), appear

to be referable to it rather than to the other American species—*L. kerteszi* var. *americanus*, nov.

♀.—Length of body (one specimen), 2·2 mm. ;* length of wing, 1·1 mm. ; length of antennae, 0·33 mm. ; width of head, 0·30 mm.

*Head* shining dark brown or blackish, the antennal depressions cinnamon-coloured, clothed with short dark hairs on the vertex and occiput ; clypeus dark brown, with twelve hairs—five on each side and two central ; eyes separated by a space equal to about one-third the width of the head. Proboscis black. Palpi (fig. 2, *b*) blackish brown ; third segment greatly swollen, with the orifice of the sensory pit large, more or less ovate, occupying the distal two-thirds of the inner side ; fourth segment subcylindrical, distinctly (one-fifth) shorter than the third. Antennae (fig. 5, *h*) short, dark brown, with greyish hairs and moderately long, curved spines ; fourth to thirteenth segments transversely oval, from 0·6 to 0·8 as long as broad ; fourteenth segment slightly more than twice as long as wide, equal in length to the three preceding segments together. *Thorax* shining black or blackish brown, sparsely clothed with short dark hairs ; scutellum with three pairs of black bristles, the central pair large. *Wings* whitish, the anterior veins terminating in a brown stigma at some distance before the middle, arranged as in fig. 8, *e* ; fifth vein bifurcating below the ends of the costal and third veins. Halteres white, the stems infuscated. *Legs* blackish brown, the tarsi paler brown ; metatarsi and second tarsal segments without spines except at the extremities. Claws simple, equal, each with a basal bristle. *Abdomen* brown, distinctly paler than the head and thorax, with short dark hairs. Lamellae brown, 0·18 the length of the wing. Spermathecae two, highly chitinised, subspherical (diameter 36$\mu$) ; the commencement of the duct scarcely chitinised.

♂.—Length of body (one specimen), 1·9 mm. ; length of wing, 1·1 mm. ; length of antennae, 0·71 mm. ; width of head, 0·30 mm.

General coloration apparently (so far as can be judged from a balsam preparation) dark brown or blackish, the tarsi paler. *Head* : frons bare, occiput and vertex with scanty hairs ; clypeus with two pairs of short hairs, eyes widely separated, the space between them being two-fifths the width of the head. Palpi : third and fourth segments sub-equal, the third slender, the sensory organ situated in the distal half. *Antennae* (fig. 4, *h*), very similar to those of the male *L. bezzii* (*q.v.*), but with the basal segments of the flagellum less compressed, the fourteenth segment relatively shorter (about three and one-half times as long as wide, and slightly more than one-third the length of the last segment), and the fifteenth segment more strongly swollen distally ; fourth to thirteenth segments varying from 0·6 to twice the width, fifteenth segment nearly eight times as long as the greatest width (*i.e.*, near the distal extremity), fourteenth and fifteenth segments, taken together, about equal in length to the preceding seven segments united. *Thorax* : scutellum with two pairs of bristles.† *Legs* slender, especially the middle and hind pairs ; metatarsi of the four anterior legs with a few small spines (usually one pair at the base and apex and one, unpaired, near the middle), hind metatarsi and second tarsal segments with a pair of spines or spine-like bristles at the apex. Claws of the fore and middle legs equal, one with a long basal tooth (fig. 4, *b*), the other with a bristle ; of the hind legs equal and simple. *Hypopygium* : Unfortunately the single preparation available is not in a sufficiently good condition to allow a satisfactory interpretation of the detailed structure of the intermediate appendages, but the claspers (fig. 4, *a*) are of peculiar form and will probably provide specific characters.

* Townsend gives the length of the body (including the lamellae) as 1·6 mm. to 2·2 mm. according as the abdomen is empty or distended with blood.

† The characters afforded by the wings cannot be determined in microscopical preparations with any degree of accuracy, unless the specimen is stained. In addition, the wings in the specimen described were considerably twisted.

*Habitat.* U.S.A.—New Mexico: Continental Divide, 7,000 ft., 21st June, (*C. H. T. Townsend*—type series), Organ Mountains, 5,700 ft., 29th Aug. (*C. H. T. Townsend*—♀♀ described above); Las Vegas Hot Springs (*H. S. Barber*— ♂ described above).

Dr. Aldrich informs me that, besides the localities mentioned above, the *Leptoconops* material in the United States National Museum includes females from Arizona, Colorado, Florida, Texas, Utah and Cuba, and males from Arizona. The specimens from Utah are *L. kerteszi* var. *americanus*, nov., but the others have not yet been definitely determined, and are provisionally referred to *L. torrens*.

Pratt (1907) mentions several of the foregoing localities, including Utah, in connection with *L. torrens*.

**Leptoconops bezzii,** Noé.

*Mycterotypus bezzii*, Noé, Atti R. Accad. Lincei, Ser. 5, Rendiconti xiv, p. 114 (1905); Arch. Zool. Napoli, iii, p. 137 (1907).

*Leptoconops hyalinipennis*, Kieff., Ann. Mus. Nat. Hung. xvi, p. 33 (1918).

The following description of *L. bezzii* (♀) is drawn up from specimens collected in Central Italy and sent me by Professor M. Bezzi; to this gentleman I am also indebted for the loan of microscopical preparations of the palpi and antennae of the type male.

♀.—Length of body (two specimens), 2·1 mm.; length of wing, 1·2 mm.; length of antenna, 0·56; width of head, 0·45 mm.

*Head* black, clothed on the vertex and occiput with short dark hairs; clypeus black or blackish brown, with two pairs of short dark hairs; eyes moderately widely separated, the space between them about one-quarter the width of the head; frons with a pair of short hairs near the lower margins of the eyes. Proboscis dark brown, Palpi dark brown, with dark hairs; third segment strongly incrassate, the orifice of the sensory pit very large, narrowly oval, extending almost the entire length of the inner side; fourth segment subcylindrical, slightly shorter than the third. *Antennae* dark brown, with short dark hairs and clear spines, which are somewhat strongly curved on the distal segments; fourth to thirteenth segments transversely oval to subspherical, the length from 0·8 to 1·0 the breadth; fourteenth segment about two and one-quarter times as long as broad, equal in length to the preceding two and one-third segments together. *Thorax* black, sparsely clothed with short black hairs; scutellum black, with three pairs of dark bristles (one of the small lateral bristles sometimes wanting); postscutellum, pleurae and pectus black. *Wings* white, iridescent, the anterior veins arranged as in fig. 8, *f*; fifth vein bifurcating slightly beyond the end of the costa. Halteres white. *Legs* dark brown or brownish black, the metatarsus and second tarsal segment paler, yellowish brown, each with a pair of apical spines. Claws (fig. 4, *d*) equal, each with a stout basal tooth. *Abdomen* dark brown, clothed with short black hairs. Lamellae yellowish brown, 0·2 the length of the wing. Spermathecae two, heavily chitinised, oval (70$\mu$ by 54$\mu$); the commencement of the duct only chitinised.

The male obtained and associated with this species by Noé differed from the female chiefly in regard to the palpi, antennae, claws and wings. The antenna consists of fifteen segments, the third (*i.e.* the first segment of the flagellum) being produced basally into a relatively long stalk, and causing the flagellum to be more distinctly separated from the basal segments than in the female; the fourth to thirteenth segments become progressively longer and narrower, the most proximal segment being very short and broad (0·4 to 0·7 the length), with chitinous thickenings on the distal margins, the thirteenth subspherical basally but produced anteriorly

(the greatest width being 1·8 the length); the fourteenth and fifteenth segments greatly elongate, the former about half the length of the latter, and when united almost equal in length to the remaining segments of the flagellum taken together. The palpi are longer and more slender than in the female, the third segment elongate, scarcely swollen, with the proximal two-thirds of the inner side excavated, the fourth segment somewhat swollen distally, approximately four-fifths the length of the third. The wings are more delicate, and (from Noé's figure, not his interpretation) the first and third veins appear to be fused basally, and to enclose a large interspace distally; the separate distal portion of the first vein is very short and directed abruptly upwards towards the costa, the separate portion of the third vein long, extending at first almost parallel with the costa, then curving gradually upwards to meet it a short distance beyond the middle of the anterior border and above the bifurcation of the fifth vein. The claws, according to Noé, are dissimilar, those on the anterior legs being provided with a long basal tooth, those on the hind legs simple, with a short basal bristle.

Kieffer's description of *L. hyalinipennis* agrees so closely with Noé's description of *L. bezzii*, and with the specimens at my disposal, that I have no hesitation in placing it as a synonym of the latter species.

*Habitat.* *L. bezzii* is now known to occur in the Roman Campagna, Central Italy, and (as *L. hyalinipennis*) in Tunis (Djebel Djeloud; Korbons; Aouina, Lac Bahira; Tunis, Parc Belvedere).

**Leptoconops flaviventris,** Kieff.

*Leptoconops flaviventris*, Kieff., Ann. Mus. Nat. Hung. xvi, pp. 34 and 85 (1918).

Kieffer's description of the female of this species is as follows:—

"♀.—Semblable à *L. hyalinipennis*, sauf les caractères suivants: Bouche plus longue que la hauteur de la tête, dirigée en arrière. Palpes de 3 articles, dont le 1er est mince et un peu plus long que gros, seulement un article après laflexion, comme chez *hyalinipennis*. Antennes à articles 3-12* très transversaux, soies sensorielles plus courtes que les poils des verticilles, 13e en ovoide allongé, sans verticille, au moins aussi long que les précédents réunis. Mesonotum luisant. Ailes blanches, nervures très pâles. Tarses blanchâtres, articulations sombres. Abdomen jaune soufre. L. 1·3 mm.

Djebel Tunisie. Djeloud (5♀)."

On a later page Kieffer recorded additional specimens, including a male from Asia Minor—"Kyaldja-Su, viii (Naday), 1 ♂; Emirley; Sulejman, H. Yayla; Karapunat, 7 ♀ (Naday)." The male, which he doubtfully associated with this species, is shining black, with brown legs and a pale brown abdomen, but from the description given it is difficult to select any very definite characters by means of which it may be distinguished from the male of *L. bezzii*. Kieffer, however, states that the proboscis is very long and slender—much longer than the height of the head—and that the metatarsi are devoid of spines. Segments four to thirteen of the antenna appear to be similar in form to those of the Italian species, but the distal portions of these organs were evidently damaged, and Kieffer was unable to determine whether fourteen or fifteen segments were present. The claws are merely described as long (more than half the length of the fifth tarsal segment), but apparently the association with *L. flaviventris* would imply that on some of the legs, at least, they are also toothed.

* In this and subsequent direct quotations the number of the antennal segment given by the author cited must, for correctness and uniformity, be increased by one; but in all the descriptive extracts given this change has already been made.

Of the species of *Leptoconops* occurring in the Mediterranean littoral *L. flaviventris* apparently most closely resembles *L. irritans* in general facies. In both species the abdomen is normally pale in colour—whitish or yellowish—but they should be easily separated by the structure of the claws.

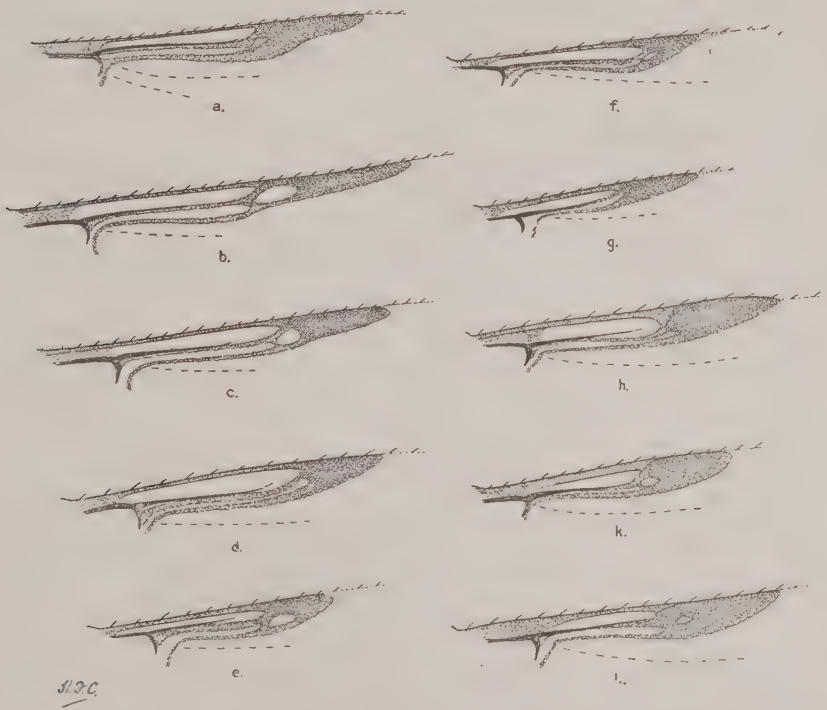


Fig. 8. Basal portions of wings of females of: (*a*) *L. stygius*, Sk.; (*b*) *L. longicornis*, sp. n.; (*c*) *L. grandis*, sp. n.; (*d*) *L. siamensis*, sp. n.; (*e*) *L. torrens*, Twns.; (*f*) *L. bezzii*, Noé; (*g*) *L. braziliensis*, Lutz; (*h*) *L. kerteszi*, Kieff.; (*k*) *L. kerteszi* var. *americanus*, n.; (*l*) *A. spinosifrons*, sp. n. (*b*, *c*, *d*, × 50 circa; the rest × 75).

**Leptoconops indicus,** Kieff.

*Schizoconops indicus*, Kieff., Ann. Mus. Nat. Hung. xvi, p. 135 (1918).

This species was made the type of the genus *Schizoconops* by Kieffer on account of its toothed or bifid ungues. This character alone, however, cannot be considered of sufficient importance to warrant the creation of a new genus; and even were it of subgeneric value the name *Schizoconops* would sink under *Mycterotypus* (see p. 3).

The chief characters, taken from Kieffer's description, are as follows:—

♀.—Shining black. *Antennae* brown, the fourth to the thirteenth segments transverse, at least twice as broad as long; fourteenth segment conical, equal in length to the four preceding segments together. *Wings* white, with pale veins; first and third veins not reaching the middle of the anterior border, fifth vein bifurcating much beyond the extremity of the third vein. Halteres white. *Legs* pale

brown, tarsi whitish, metatarsi without spines ; anterior femora slightly thickened ; claws bifid, equal, the branch shorter. *Abdomen* red ; lamellae long and whitish.

*Length* 1·5 mm.

*Habitat.* Bengal : Champaran, Bettiah, iii, 1908.

This species should be easily recognised by the structure of the claws, the absence of spines on the metatarsi, and the relative positions of the extremity of the third vein and bifurcation of the fifth vein ; that the latter should take place considerably beyond (" très distale ") the junction of the third vein with the costa is unusual.

**Leptoconops siamensis,** sp.nov.

♀.—Length of body, 3·5 mm. ; length of wing, 1·8 mm. ; length of antenna, 0·6 mm. ; width of head, 0·43 mm.

Head dull brown, the antennal depression creamy-white, clothed with dark brown hairs on the occiput ; clypeus rather paler brown, with four dark brown hairs on each side of the middle line ; eyes relatively not very widely separated, the space between them almost one-fifth the greatest width of the head and devoid of hairs. Proboscis pale brown. Palpi (fig. 2, *f*) pale brown, with brown hairs ; third and fourth segments elongate, subequal ; the third strongly incrassate, with a deep sensory pore, the orifice of which is very large and occupies almost the entire length of the inner side. *Antennae* moderately long, yellowish brown, with short pale brown hairs and slightly curved, pointed, transparent spines ; segments 4 to 13 subspherical to oval, the length varying from 0·8 to 1·3 times the breadth ; terminal segment (fig. 5, *a*) elongate, equal in length to the preceding two and one-third segments together. *Thorax* : disc dark umber-brown, pollinose, clothed with short brown hairs ; prothoracic lobes and humeral callus yellowish brown ; scutellum and postscutellum rather darker than the disc, the former with three pairs of strong median bristles and two pairs of small lateral hairs ; pleurae and pectus dark umber-brown. *Wings* whitish, venation normal, the first and third veins (fig. 8, *d*) fused distally, not forming an interspace. *Legs* entirely brownish yellow, bearing pale brown hairs and, on some of the tarsal segments, stout blackish spines ; fore femora and tibiae slightly swollen and somewhat shortened, tibia of all the legs with an apical spur ; metatarsi each with two sub-ventral or ventro-lateral rows of strong spines,* the second and third tarsal segments of the fore and middle legs each with two apical spines, of hind legs wanting. Claws (fig. 4, *f*) of fore and middle legs equal, each with a large (at least half the length of the claw) strong tooth arising from the base. *Abdomen* waxen creamy white above and below, clothed with short hairs. Lamellae brownish yellow, approximately 0·25 times the length of the wing. Spermathecae two, rather narrowly oval ($65\mu \times 38\mu$), highly chitinised ; commencement of the duct chitinised for a very short distance.

*Habitat.* Siam : Patani Cape (*H. C. Robinson & N. Annandale*). One female (type) in the British Museum Collection.

This species is not closely allied to any of the known members of *Leptoconops* (*sens. lat.*) ; it agrees with *L. indicus* in regard to the structure of the claws, but may readily be separated therefrom by its relatively large size and the powerful spinose armature of its metatarsi. In the latter character and the reduction in length of the fore legs it suggests *Acanthoconops* (*q.v.*).

* The development of these spines has not proceeded uniformly, and although normally paired, the spine on one side is often much smaller than that on the other and may be represented by a strong bristle. The number of spines present on the same segments of corresponding legs therefore varies, and on the metatarsi of the single specimen available was –fore legs 18 and 15, middle legs 14 and 15, hind legs 9 and ? (the metatarsus of the corresponding leg missing).

## Subgenus **Holoconops,** Kieff.

*Holoconops*, Kieff., Ann. Mus. Nat. Hung. xvi, p. 135 (1918).

This subgenus comprises those species of *Leptoconops* (*sens. lat.*) in which the antennae of the female are composed of thirteen segments; in all the known species the claws in this sex are simple and equal. The group was given generic rank by Kieffer, who based its separation upon the structure of the female antennae and claws. Such a combination of characters, however, cannot be maintained, since the structure of the claws is in no way peculiar, and this author's restriction of the type mentioned above to *Holoconops* is evidently due to a misconception. Kieffer designated *L. kerteszi*, Kieff., as his genotype, and, in a footnote, associated it with *L. flaviventris*, Kieff., *L. hyalinipennis*, Kieff. (synonymous with *L. bezzii*, Noé), and *L. lacteipennis*, Kieff.; but the inclusion in this group of the second and third-named species is a palpable oversight, as in his descriptions of them on preceding pages of the same article the antennae are definitely stated to possess the full complement of segments (fourteen).

Three species of this subgenus are here recognised, but one (*L. interruptus*, End.) is insufficiently described, and may subsequently prove identical with one of the others. They are widely distributed, and have been recorded from Northern Africa, Asia Minor, South West Africa and the United States of America.

### **Leptoconops kerteszi,** Kieff.

*Leptoconops kerteszi*, Kieff., Ann. Mus. Nat. Hung. vi, p. 576 (1908).

*Mycterotypus laurae*, Weiss, Arch. Inst. Pasteur de Tunis, pp. 25-32 (1912).

*Mycterotypus laurae* var. *peneti*, Langeron, Arch. de Parasit. xvi, pp. 282-301 (1913).

The synonymy given above is based upon examinations of specimens sent me as *L. kerteszi* by Mr. F. C. Willcocks from Egypt, and of females of *L. laurae* sent me by M. A. Weiss from Tunis. *L. kerteszi* was described by Kieffer from specimens collected at Cairo, and the material received from Mr. Willcocks agrees in detail with this author's descriptions. Furthermore Kieffer, who is evidently unacquainted with *L. laurae*, has recently (1918) recorded *L. kerteszi* from Tunis.

The following description is compiled from the Egyptian and Tunisian specimens referred to above.

♀.—Length of body (six specimens), 1·8–2·1 mm.; length of wing, 1·1–1·3 mm.; length of antenna, 0·33–0·42 mm.; width of head, 0·31–0·34 mm.

*Head* shining black, the antennal depressions pale buff, sparsely clothed on the vertex and occiput with short black hairs; clypeus shining black, with three pairs of dark hairs; eyes relatively widely separated, the space between them being approximately two-fifths the width of the head. Proboscis dark brown or black. Palpi (*cf.* fig. 2, *d*) dark brown, with brown hairs; third segment very strongly swollen, with a large oval pore situated near the middle, fourth segment slightly inflated distally, scarcely shorter than the third. *Antennae* (*cf.* fig. 5, *g*) dark brown, with rather long (about twice the length of the segment) pale brown hairs; fourth to twelfth segments transversely oval to spherical, from 0·8 to 1·0 as long as broad; thirteenth segment equal in length to the preceding three and one-third to four segments together. *Thorax* entirely shining black, with short black hairs; scutellum with two pairs of bristles. *Wings* white, iridescent; venation normal, the anterior veins not quite reaching the middle of the anterior border and arranged as in fig. 8, *h*; fifth vein bifurcating slightly before the extremities of the costa and third veins. Halteres whitish. *Legs* dark brown, clothed with dark hairs; metatarsi of the hind legs paler brown, with short brownish yellow hairs; fore and middle metatarsi with a basal and apical pair of slender, pointed spines, and a few (one to four) central, usually unpaired,

spines ; hind metatarsi and second segments of all the legs with a pair of similar spines at the extremities. Claws (*cf.* fig. 4, *c*) simple and equal, each with a short bristle arising from the base. *Abdomen* dark brown, the margins of some of the tergites narrowly grey, sparsely clothed with short brown hairs. Lamellae pale brown, 0·25 the length of the wing. Spermathecae two (a third very small, narrowly oval one is often present), heavily chitinised, obovate, (47$\mu$ × 36$\mu$) ; a minute portion only of the duct chitinised.

The male was described by Weiss, who stated that it was uniformly darker in colour than the female, and gave the following measurements :—Length of body, 1·5 mm. ; length of antennae (barely), 0·5 mm. Judging by this author's description and figures, it presents certain striking morphological differences from those males which have been associated with species of *Leptoconops* (*sens. str.*). The eyes are said to meet at a point above ; the palpal segments are depicted as subequal in length and about three times as long as wide ; the fourth antennal segment almost twice as long as the fifth, the fifth to twelfth short and broad, subequal, the last three segments elongate, but the thirteenth almost equal in length to the fourteenth and fifteenth taken together ; and the wings with reduced venation –the fourth vein being absent.

*Habitat.* Egypt : Cairo, Behera, Wadi Natroun, Sakkara (*Willcocks*). Tunis : Tabeditt (*Weiss*).

Willcocks (1917) states that the species was first sent from Behera in March 1907, and that it is common at certain seasons in Wadi Natroun, and in the autumn, when the Nile is in flood, from Mena House to Sakkara.

**Leptoconops kerteszi** var. **peneti,** Langeron.

♀.—Length of body, 1·5–1·8 mm. ; length of wing, 1·06 mm. ; length of antenna (from figure), 0·45 mm.

According to Langeron this variety differs from the specimens (type series) of *M. laurae* in the Paris Museum principally in being larger, darker, and possessing more numerous and stronger bristles and spines. In particular, he compares the development and exact arrangement of the metatarsal spines in the two forms. He also maintains that biological differences exist : the variety appears to persist later in the year, occurs in a more southerly region, and at a much lower altitude than is recorded by Weiss for the type form. *M. laurae* came from a mountainous region (altitude 500 metres), while the var. *peneti* was found in the desert (mean altitude 30 metres), in the marshes lying between the oases of El Hamma and the Shott Gharsa.

In view of the individual variation in regard to size, and number and arrangement of the metatarsal spines observed in a series of specimens of *L. kerteszi*, the distinguishing points cited by Langeron can scarcely be granted even varietal value ; but in this author's excellent and detailed description of his specimens, mention is made of a character which is of much greater importance, and which raises doubt regarding its specific identity. The ungual formula is stated to be 0·1—0·1—0·1, and the external claw of each leg is said to bear a small basal tooth. Such a condition occurs in no other species of *Leptoconops*, and therefore, if Langeron's interpretation be correct, the form should be easily recognised and would deserve specific rank. It should be noted, however, that in some species the base of the claw is relatively broad and projects slightly ventrally, so that, in certain positions, a minute basal tooth appears to be present.

**Leptoconops kerteszi** var. **americanus,** nov.

♀.—Length of body (three specimens), 1·75 mm. ; length of wing, 1·1 mm. ; length of antenna, 0·32 mm. ; width of head, 0·30 mm.

In spite of their widely distant places of origin I have been unable to find any satisfactory characters for separating specimens from Utah (received through the

kindness of Professor L. O. Howard and Dr. J. M. Aldrich) from typical examples of *L. kerteszi*. Indeed, allowing for minute differences which come within the range of individual variation, the only distinguishing details appear to be the formation of an interspace by the first and third veins (fig. 8, *k*) and the slightly different form of the spermathecae. These are almost spherical in the Utah specimens, whereas they are obovate in the Mediterranean examples. Males of both forms, when forthcoming and compared, may possibly reveal distinctive antennal or genital characters, but until such time the American form can, at the most, be accorded varietal rank.

*Habitat.* United States of America: Utah, Salt Lake, June, "biting devilishly" (*H. S. Barber*). Three females (cotypes) in the collections of the United States National Museum and Liverpool School of Tropical Medicine.

**Leptoconops lacteipennis,** Kieff.

*Leptoconops lacteipennis*, Kieff., Ann. Mus. Nat. Hung. xvi, p. 32 (1918).

This species, described from a female captured in Tunis, apparently differs from *L. kerteszi* chiefly in the metatarsi being devoid of spines, the segments of the flagellum more uniformly transversely oval, and the fifth tarsal segment shorter than the fourth. The last character should enable the species to be identified without difficulty, since, so far as I am aware, it is unique in this respect.

The more important of the specific characters given by Kieffer are as follows:—

♀.—Black. Fourth to twelfth antennal segments transverse (from the figure accompanying the description, the length varies from 0·6 to 0·7 times the breadth), thirteenth segment slightly longer than the three preceding segments together. Mesonotum shining. Halteres white. Wings milky white, extending almost to the tip of the abdomen; third vein reaching almost to the middle of the wing, fifth vein bifurcating slightly before the extremity of the third vein. Legs black, without spines, tarsi brown; tarsal segments 1 to 4 gradually decreasing in length, the fifth segment shorter than the fourth. Claws simple, equal, each with a bristle arising from the base. Abdomen brownish black. Length, 2 mm.

**Leptoconops interruptus,** End.

*Mycterotypus interruptus*, End., Denks. Med. Ges. Jena, i, pp. 133–162 (1908).

The description of this species given by Enderlein relates largely to characters of a general nature, and details which, in the light of our present knowledge of the group, must be considered of value in separating such closely allied forms receive little attention. Nevertheless, with the help of the figures accompanying the description, it would appear that *L. interruptus* is very close to, if not identical with, *L. kerteszi*. Weiss (1912) observed the close relationship existing between these species, and especially noted the affinities existing in regard to the spinose armature of the metatarsi and the structure of the antennae. Since, however, the exact arrangement of the metatarsal spines is not of specific importance, it seems that the only tangible differential character is afforded by the antennae. Enderlein states that the third to twelfth segments are spherical, and that the last segment is twice as long as broad; this would indicate, also, that the terminal segment was approximately equal in length to the two preceding segments together. In *L. kerteszi* the last segment is at least three times as long as broad, and is equal in length to the three to four preceding segments.

A re-examination of the type or the examination of further material from South-West Africa (Enderlein's example came from Rooibank, hinterland of Walfish Bay) is necessary, before a decision regarding the validity of one or both of these species can be made.

## Genus **Acanthoconops,** nov.*

Frons clothed with bristles or spines. Antennae in the female pilose, composed of fourteen segments, the fourth to thirteenth short and broad, subspherical, the fourteenth elongate, subconical. Eyes, palpi, proboscis and wings as in *Leptoconops*, Sk. (*sens. lat.*). Fore legs relatively short, the fore and hind femora and tibiae strongly incrassate, the middle femora moderately incrassate; claws equal, each with a tooth arising from the base; empodium bristle-like. Ovipositor somewhat triangular, very short, considerably broader than long.

Genotype: *A. spinosifrons*, sp. nov.

This genus is very closely allied to *Leptoconops* (*sens. lat.*), but may readily be distinguished by the remarkably short ovipositor (fig. 9), and by the vestiture of the head. In *Leptoconops* (*sens. lat.*) the whole of the frons (*i.e.*, the wide area extending from the vertex to the clypeus) is bare, or, at most, possesses a single pair of bristles between the eyes, while in *Acanthoconops* it bears numerous spines or bristles (*cf.* fig. 1, *a* and *b*). Further, in the two species of *Acanthoconops* at present known the fore legs are noticeably shortened, and the metatarsi of all the legs armed with formidable spines. The ratio of the combined lengths of the femora and tibiae of the fore legs to those of the hind legs is 1 : 1·5, or but slightly less; in *Leptoconops* this ratio is rarely more than 1 : 1·2, and not infrequently is 1 : 1. In this connection it may be of interest to note that, among the members of the latter genus, the ratio given for *Acanthoconops* is (so far as can be determined from the material available) most nearly approached in the case of *L. siamensis*, sp. n. In this species, which also possesses powerful spines on the metatarsi, the ratio is almost 1 : 1·4.

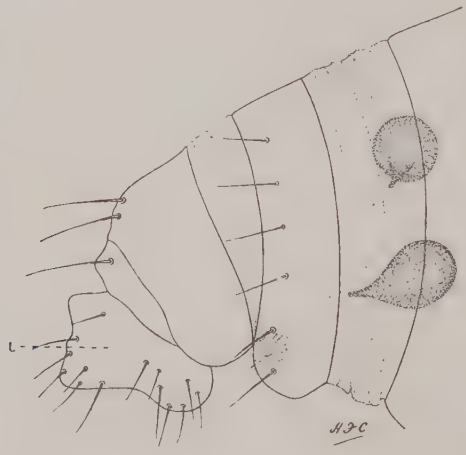


Fig. 9. Extremity of abdomen of *Acanthoconops spinosifrons*, sp. n., ♀, showing lamellae (*l*); side view (× 220 circa).

**Acanthoconops spinosifrons,** sp. nov.

♀.—Length of body (two specimens mounted in Canada balsam), 2·3 mm.; length of wing, 1·2 mm.; length of antenna, 0·35 mm.; width of head, 0·32 mm.

*Head* dull black, with short, stout, pointed, backwardly directed, tuberculate spines scattered over the occiput and frons, on the lower portion of which they are more numerous; clypeus shining dark brown, with a group of spines centrally and a

* ακανθα spine, and κωνωψ gnat.

few (three pairs) relatively short black hairs ; eyes widely separated above and below, the space between them at the vertex being rather more than one-third the greatest width of the head. Proboscis dark brown. Palpi (fig. 2, *e*) dark brown, the apical segment yellowish brown, clothed with short dark hairs ; apparently composed of three segments, the two small basal segments being almost fused together ; orifice of the sensory pit in the third segment small, subcircular, situated in the proximal third. *Antennae* (fig. 5, *f*) relatively short, dark brown, with short glistening hairs and short, straight or slightly curved spines ; segments 4 to 13 transversely oval to subspherical, the length varying from 0·6 to 0·8 of the breadth, the fourteenth

Fig. 10. *Acanthoconops spinosifrons*, sp. n., ♀ : *a*, front leg (× 85) ; *b*, first and second tarsal segments of front leg (× 295) ; *c*, hind leg (× 85) ; *d*, first and second tarsal segments of hind leg (× 295) ; *e*, fifth tarsal segment of hind leg (× 550).

segment equal in length to the preceding two and one-half segments together. *Thorax* and scutellum shining black, the dorsum clothed with short brown hairs ; scutellum bearing two pairs of large, and one or two pairs of small bristles ; pleurae and pectus shining black. *Wings* glassy, strongly iridescent ; the anterior veins as shown in fig. 8, *l*, the fifth vein bifurcating almost immediately below the extremity of the third vein. Halteres with white knobs and infuscated stems. *Legs* (fig. 10) pale brown, the distal two-thirds or three-fourths of the femora, and the distal third of the fore and hind tibiae, black, clothed with brown hairs ; tibiae each with a strong apical spur, fore tibiae incrassate, hind tibiae with five strong, blunt, black spines on

the outer side at the apex, and with three of the bristles of the posterior transverse distal row (situated on the inner aspect) replaced by similar but smaller spines; metatarsi, particularly those of the hind legs, short, fore and hind metatarsi incrassate; fore and hind tarsi with stout, blunt black spines arranged as shown in fig. 10, middle tarsi with six or seven pairs of similar spines on the first segment and the apical bristles of the second and third segments differentiated—spine-like. Claws (fig. 10, *e*) equal, the basal tooth stout. *Abdomen* translucent creamy white, but appearing in engorged or partly fed specimens dark brown or cream-coloured, with dark central bands on the proximal segments; clothed with pale hairs. Lamellae creamy white, clothed with pale hairs. Spermathecae two in number, heavily chitinised, oval ($53\mu \times 37\mu$); the commencement of the duct chitinised for a relatively long distance ($18\mu$).

*Habitat.* Zanzibar (*Dr. W. M. Aders*), seven females (including three cotypes). The labels attached to the specimens bear the following data: on buffalo; Pigaduri, Zanzibar, 13.iv.19. In the collection of the Imperial Bureau of Entomology.

**Acanthoconops albiventris,** de Meijere.

*Leptoconops albiventris*, de Meijere, Tijds. voor Ent. lviii, p. 98 (1915).

*Leptoconops spinosipes*, Kieff., Ann. Mus. Nat. Hung. xv, p. 190 (1917).

♀.—Length of body (two specimens), 1·8 mm.; length of wing, 1·0 mm.; length of antenna, 0·3 mm.; width of head, 0·32 mm.

Through the courtesy of Professor de Meijere, I have been able to examine females of this species, which was described by him from specimens collected in New Guinea. This author noticed and commented upon the unusual form of the lamellae, but retained the species in *Leptoconops*, and apparently did not observe closely the arrangement of the hairs on the head; this he stated was "kaum behaart." *A. albiventris* is closely allied to the preceding species, but is smaller, and possesses somewhat less powerful, though similarly arranged, spines on the legs. Morphologically, it may readily be separated from *A. spinosifrons* by (1) the frons bearing numerous short hairs or bristles instead of spines; (2) the terminal segment of the antennae being relatively longer (equal in length to the preceding three and one-third segments instead of the preceding two and one-half); (3) the bristles forming the posterior transverse distal row on the hind tibiae all being normal, none replaced by spines; (4) the hind metatarsus being relatively longer (about one-half the length of the tibiae, whereas in *A. spinosifrons* it is about one-third the length); and (5) the tooth of the claws being distinctly smaller.

The synonymy given above seems extremely probable from a comparison of the descriptions, and in view of the fact that Kieffer's specimens also came from New Guinea (Tamara, Berlinhafen). Discrepancies in the descriptions are slight, and Kieffer's statement that the abdomen is red, sometimes white, with brownish markings, is of little consequence, as it suggests that some (possibly most) of his examples were wholly or partly engorged with blood.

This species appears to be a vicious biter and, at times, a serious pest in parts of New Guinea; K. Gjellemp, the collector of de Meijere's material, attached the following information to the specimens—"An der Mundung des Sermowai-Flusses in sehr grosser Anzahl vorhanden und durch ihr Stechen eine grosse Plage bildend, 16 Mai 1911."

The distinguishing characters of the known species (females) of *Leptoconops* (*sens. lat.*) and *Acanthoconops* are summarised in the following table.

(1) Lamellae elongate; frons bare or with a single pair of hairs between the eyes (*Leptoconops, sens. lat.*) .. .. .. .. .. .. 2

Lamellae very short; frons with numerous spines or hairs (*Acanthoconops*) 17

(2) Antennae composed of fourteen segments (*Leptoconops, sens. str.*) .. .. 3
Antennae composed of thirteen segments (*Holoconops*, subgen.) .. .. 13
(3) Claws simple .. .. .. .. .. .. .. .. .. 4
Claws toothed .. .. .. .. .. .. .. .. .. 10
(4) Metatarsi with distinct spines .. .. .. .. .. .. .. 5
Metatarsi without spines (excluding the pair at the apex) .. .. .. 6
(5) Abdomen whitish or yellow; lamellae approximately one-fifth the length of the wing .. .. .. .. .. .. *irritans*, Noé (p. 14).
Abdomen dark brown; lamellae approximately one-third the length of the wing .. .. .. .. .. .. *braziliensis*, Lutz (p. 13).
(6) Fifth vein bifurcating considerably beyond extremity of costa .. .. *rhodesiensis*, sp. n. (p. 14).
Fifth vein bifurcating before or below extremity of costa .. .. .. 7
(7) Third palpal segment greatly swollen; antennal segments 4–13 distinctly broader than long (American species) .. .. *torrens*, Twns. (p. 15).
Third palpal segment elongate, slightly swollen; antennal segments 4–13 subspherical or longer than broad (Australian species) .. .. .. 8
(8) Smaller species (wing length 1·3 mm.); last antennal segment less than twice as broad as long .. .. .. .. *stygius*, Skuse (p. 10).
Larger species (wing length 2·0 mm.); last antennal segment more than three times as broad as long .. .. .. .. .. .. 9
(9) Antennae very long, last segment at least six times as long as broad .. *longicornis*, sp. n. (p. 11).
Antennae shorter, last segment at most three and one-half times as broad as long.. .. .. .. .. .. .. *grandis*, sp. n. (p. 12).
(10) Metatarsi with very large spines .. .. .. *siamensis*, sp. n. (p. 20).
Metatarsi without spines (excluding the pair at the apex) .. .. 11
(11) Antennal segments 4–13 transversely oval to spherical, the last segment slightly longer than the two preceding together .. .. *bezzii*, Noé (p. 17).
Antennal segments 4–13 all broader than long, the last segment as long as the three or four preceding together .. .. .. .. .. 12
(12) Abdomen yellow; last antennal segment as long as the three preceding together .. .. .. .. .. *flaviventris*, Kieff. (p. 18).
Abdomen red; last antennal segment as long as the four preceding *indicus*, Kieff. (p. 19).
(13) Metatarsi without spines; fifth tarsal segment shorter than fourth .. *lacteipennis*, Kieff. (p. 23).
Metatarsi with distinct spines; fifth tarsal segment longer than fourth .. 14
(14) Last antennal segment twice as long as broad, segments 4–12 spherical .. *interruptus*, End. (p. 23).
Last antennal segment three to four times as long as broad, segments 4–12 transversely oval to spherical .. .. .. .. .. .. 15
(15) Claws equal, one simple, the other with a minute basal tooth .. .. *kerteszi* var. *peneti*, Langeron (p. 22).
Claws equal and simple .. .. .. .. .. .. .. 16
(16) Spermathecae obovate, narrow anteriorly (Mediterranean Region) .. *kerteszi*, Kieff. (p. 21).
Spermathecae subspherical (America) *kerteszi* var. *americanus*, n. (p. 22).

(17) Frons spiny (Tropical Africa) .. .. .. *spinosifrons*, sp. n. (p. 24).
Frons hairy (New Guinea) .. .. .. *albiventris*, Meij. (p. 26).

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# MOSQUITO BREEDING IN SALINE WATERS.

By Andrew Balfour, C.B., C.M.G., M.D.

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In the " Bulletin of Entomological Research " for December 1920 Dr. J. M. Dalziel deals in a most interesting and instructive way with the various, and sometimes curious breeding-places of mosquitos in Lagos. He mentions the occurrence of mosquito larvae in saline waters, and in a foot-note refers to a number of salt-water species.

The subject of mosquitos breeding in salt and brackish waters possesses not only considerable scientific interest, but is of practical importance in anti-malarial work, for the suggestion has frequently been made to abolish ordinary mosquito breeding-places by the introduction of salt or of sea-water, and in some instances this procedure has actually been carried into effect. As will be seen, in the case of certain species of mosquitos it is useless or worse than useless.

Moreover, there is the question of the efficiency of larvicides in saline waters, a matter to which attention has been directed, but on which, so far as I know, our information is still defective.

It may therefore be of interest to refer a little more fully to the subject than Dr. Dalziel has done, although at the present time I am unable to deal exhaustively with the matter, and, after a few remarks, propose merely to supply some annotated references supplementary to those furnished by Dr. Dalziel, and dealing almost entirely with mosquitos known to be vectors of disease.

I hope that Mr. MacGregor, in charge of our Entomological Field Laboratory at Wisley, in Surrey, may be able to carry out some research on the question in the ensuing spring and summer, so far as it concerns indigenous species of mosquitos.

My attention was first specially directed to the subject when Mr. Harold King, the Entomologist of the Wellcome Tropical Research Laboratories at Khartoum, found *Culex sitiens*, Wiedemann (*salus*, Theobald), larvae in sea-water at Port Sudan, a fact to which Dr. Dalziel refers in his paper, and when, at Khartoum, I found *Anopheles* (*Pyretophorus*) *costalis*, Loew, breeding freely in brackish pools formed by seepage through the " weeping soil " of irrigation channels in Khartoum North. I had the water of these pools analysed, but unfortunately cannot find the record. I think, however, I am correct in saying that it contained at least 2 per cent. of common salt.

Hence this Anopheline can breed in waters similar to those in which, as Dr. Dalziel mentions, Willcocks in Egypt found the larvae of *Anopheles multicolor*, Camboulin, or, as it used to be called, *Pyretophorus cleopatrae*. This is of interest in view of the fact that Graham recommended the salting of water containing the larvae of *A. costalis*. He added common salt in the proportion of 3 per cent., and found that it caused disintegration and precipitation of the motile algae upon which the larvae feed. The latter, being thus deprived of their natural food, become cannibalistic. Salt, he says, in lesser concentration appears to inhibit the growth of young larvae, probably by diminishing their food supply, but seems to hasten the fully-grown larvae, which become pupae more rapidly than usual.

As a matter of fact Dutton in 1902 had already shown that in the Gambia *A. costalis* could breed in salt-water pools. Its larvae were found along with those of *Culex thalassius*, Theobald.

Apparently Grassi in Italy was the first to direct attention to Anophelines breeding in sea-water. Nuttall, Cobbet and Strangeways-Pigg took the larvae of *Anopheles maculipennis*, Meigen, in brackish water in England—twice in ditches, four times in pools—and Christophers and Stephens discovered Anopheline larvae in brackish pools at Accra containing 0·6 per cent. salt.

Amongst the more important of the earlier investigations is that by de Vogel in the Dutch East Indies. As Howard, Dyar and Knab point out, he disproved certain conclusions of the Italian authors Perrone and Vivante, who stated that the maximum proportion of sodium chloride in water which the larvae of Anophelines could resist was under 2 per cent. Working chiefly with the larvae of *A. rossi*, Giles, de Vogel found that a considerably higher percentage of sodium chloride, *i.e.*, as much as 2·88, was not detrimental. His summary was as follows :—

"1. There are species of *Anopheles* which can live very well in sea-water.

"2. These mosquitos lay eggs which develop even in sea-water which has been evaporated to half its original quantity.

"3. These larvae in the gradually evaporating pools of sea-water can stand an evaporation of the water to one-third of its bulk, but do not appear to transform to adults if the concentration be greater than this.

"4. The larvae coming from eggs laid in sea-water of high concentration can accomplish their entire metamorphoses in almost the normal time. This is true even when the water has such concentration that the development of larvae originally hatching in unconcentrated sea-water would be retarded by this salt water."

Later work by Carruthers and Christophers in the Andamans and also by Banks in the Philippines and Swellengrebel in Java, suggests that de Vogel was probably dealing with *A. ludlowi*, Theobald, rather than with *A. rossi*, the two mosquitos being very similar.

A comparatively early record is that by Foley and Yvernault, who, in 1907, found *Pyretophorus chaudoyei*, Theobald, breeding in Algerian waters of which the salinity was greater than that of sea-water. *P. chaudoyei* is now called *A. multicolor*, an Anopheline which comes very near *A. hispaniola*, Theobald, which, again, is probably identical with the well-known Egyptian species *A. turkhudi*, Liston. As regards the last-named, Gough has recorded the occurrence of its larvae in a brook of highly saline water at Helouan, and succeeded in rearing them from water containing 2 per cent. of salt. On the other hand Willcocks (*loc. cit.*) found that a 1 per cent. salt solution proved fatal to the larvae of *A.* (*Cellia*) *pharoensis*, Theobald, a common Anopheline of Egypt.

Banks in 1908 showed that in the Philippines *A. ludlowi*, Theobald, a mosquito mentioned by Dr. Dalziel in relation to the Andamans, breeds in both salt and fresh water, and that in certain places they were present in water strongly impregnated with lime and also containing much aluminium sulphate.

Clerc in France found the larvae of a Culicine, *Ochlerotatus*, (*Culicada*) *cantans*, Meigen, in sea-water containing 44 grammes of chloride of sodium to the litre, and recorded his observations in 1909. He noted that these larvae survive when transferred to fresh water, whereas, on the other hand, if the young larvae of *A. maculipennis* are placed in salt water they die. The older larvae, however, survive and become pupae and imagines.

In 1910 Gholap at Bombay discovered the larvae of *A. stephensi*, Rothwell, in sea-water. The ponds in which they were found contained vegetable growths.

North American work on the subject, so far as Anophelines are concerned, includes the observations of Chapin, who in Rhode Island found *Anopheles* larvae flourishing in brackish coastal waters, and those of Smith on the larvae of *A. quadrimaculatus*, Say, in the saline waters of New Jersey, and the records demonstrating the breeding of *A. crucians*, Wiedemann, in similar localities both in New Jersey and Louisiana.

*Stegomyia fasciata*, Fabricius, figures in the list of mosquitos given by Dr. Dalziel as breeding in boats and canoes, the water in which was for the most part brackish.

Hence it is of interest to note that in Somaliland Drake-Brockman recorded the co-existence of *Stegomyia* larvae with those of *Culex sitiens*, and stated that brackish well-water was acceptable to the former.

Macfie experimented with the larvae of *Stegomyia fasciata* at Lagos in the hope of finding that common salt might be used as a larvicide in the case of this mosquito. He showed that as regards domestic utensils the saline solution required to be of a strength of 2 per cent. to ensure destruction of the larvae. Water containing 0·5 per cent. of sodium chloride had no appreciable effect upon them.

Fielding, working at Townsville, Queensland, found that the female *Stegomyia fasciata* oviposited in 70 per cent. sea-water.

Darling demonstrated the fact that in Panama *Stegomyia fasciata* could breed in brackish water of varying chlorine content and that such water could also harbour the aquatic stages of *A. pseudopunctipennis*, Theobald, *A. malefactor*, Dyar & Knab, and *Culex taeniorhynchus*, Wiedemann. In swamps containing 80 per cent. and more of sea-water he found the larvae of *A. albimanus*, Wiedemann, and *A. tarsimaculatus*, Goeldi, present in enormous numbers. Similar observations as regards *A. albimanus* were also made by Jennings of the Isthmian Canal Commission.

According to Peryassú the larvae of *A. argyritarsis*, Robineau-Desvoidy, in Brazil are found in strongly brackish water as well as in fresh water.

Howard, Dyar and Knab mention that certain Brazilian observers, experimenting with the larvae of *A. albimanus* and *A. argyritarsis*, "found that in slightly brackish water imagos were produced in a normal manner. In a mixture of 19 per cent. of sea-water with fresh water only a very small proportion of larvae transformed to imagos. Beyond this the larvae failed to pupate; with 20 per cent. sea-water some of the larvae survived three days; with 30 per cent. all died after one day."

Recent work by Taylor and Fielding in Queensland, Australia, shows that *A. annulipes*, Walker, is occasionally found breeding in salt waters.

The latest research into the question of the occurrence of the larvae of Anophelines in saline waters appears to be that by Sella, who had charge of the anti-malaria campaign at Fiumicino, near Rome. His observations were carried out on the larvae of *Anopheles maculipennis* or, as he calls it, *A. claviger*, and showed that a salinity up to 6–7 per 1,000 of sodium chloride was without effect. Laboratory experiments were also conducted, which indicated that the development of larvae is inhibited at an early stage by concentrations of above 13–14 per 1,000, and that even those exceeding 9 per 1,000 are no longer favourable to development. Pupae, however, are able to tolerate a very strong concentration. From the point of view of the employment of brackish waters in anti-malarial work it is interesting to note that the investigations showed that solutions exceeding 20 per cent. must be employed in order to ensure destruction within 10 hours, and exceeding 18 per cent. to obtain this result within 24 hours. Further, it has been shown that larvae which have been subjected to the action of the saline solution for several hours, if transported into fresh water before they are dead, will survive. Apparently, to judge from cage experiments, adult Anophelines are not influenced in laying by the mere salinity of the water.

So far as *Stegomyia fasciata* is concerned, its behaviour as regards brackish waters and sea-water has also formed the study of French and Brazilian observers, as recorded by Howard, Dyar and Knab in their important and comprehensive work on the mosquitos of North America.

Dr. Dalziel's note on the various species of *Culex* found breeding in the coastal salt marshes of the United States of America doubtless refers to the observations of Chidester, who made an exhaustive study of the subject.

As regards the action of larvicides in saline waters the experiments of Jacob in the Panama Canal Zone may be cited. Employing the well-known preparation devised for use in that area and consisting of so-called "crude carbolic acid," resin and caustic soda, he proved by laboratory tests that the mineral salts in the salt water do not lessen the toxicity of the larvicide. Moreover, if the larvicide be added as an emulsion (and it is essential that this should be the case, for the sodium salts of the cresols remain insoluble in sea-water), its entire quantity remains on the surface, where it is found deadly to mosquito larvae. Jacob sums up to the effect that

> "When all other conditions are the same, the larvicide applied in an emulsified state is more efficient in brackish water than it is in fresh water, and when brackish water is to be treated, the area of the surface of the water is the only factor necessary to be considered in determining the quantity of larvicide to be used."

Perry, commenting on this work, stated that his experience in the field confirmed the above results.

I have not been able to find records as regards the use of other larvicides in brackish waters, but lack of time has prevented an exhaustive search of the literature, in which, however, I believe there are but few references to the subject.

Mosquito larvae have been found in waters containing chemical constituents other than the marine salts, for example, aluminium sulphate, as already mentioned. Some of them, indeed, even survive in solutions which *a priori* one would imagine should speedily kill them. A consideration of these strange and sometimes sulphurous nurseries would, however, lead us too far afield, but it might well form the subject of another paper containing statements which, though perfectly true, might easily be regarded as incredible.

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# ON SOME BORNEAN FIG-INSECTS (AGAONIDAE —HYMENOPTERA CHALCIDOIDEA).

By James Waterston, B.D., B.Sc.

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The following notes deal with the Agaonidae represented in a small collection of fig insects formed in 1907–8, in Sarawak, by Mr. J. Hewitt, now Director of the Albany Museum, Grahamstown, South Africa.

## Genus **Blastophaga,** Grav.

**Blastophaga jacobsoni,** Grnd.

*Blastophaga jacobsoni*, Grandi, Boll. Lab. Zool. Portici, x, pp. 126 and 127, 26th April 1916, and *ibid.* xii, pp. 21–32, figs. vii–x, 1917.

Four ♀ ♀ "From a fig."

Borneo: Siol, Sarawak, viii. 1908 (*J. Hewitt*).

In none of these specimens is the antenna complete beyond the sixth joint. Dr. Grandi, who has at my request kindly compared this material with the type (which was described from fruit of *Ficus procera*, Reinw., var. *crassiramea*, King, from plants in the Botanical Garden, Buitenzorg, Java), is satisfied that it is referable to his species, although the first mid-tarsal is not longer than the second, and the pilosity of the thorax is not quite typical.

The range of *Ficus procera* and its var., so far as I can ascertain, is Java and Sumatra. The species may, however, have been introduced into Borneo.

## Genus **Ceratosolen,** Mayr.

**Ceratosolen hewitti,** sp. nov.

♀.—Head wider (10 : 9) than long (deep). Clypeal lobes large and very prominent (fig. 1, *a*), central tooth short, keel distinct. Distance between the lower corner of the eye and the base of the mandible slightly longer than the depth of the eye. Antenna, length 0·9 mm. (fig. 1, *b*); the scape viewed from beneath (fig. 1, *c*) and outwardly shows a remarkable obliquely-set thickish edge or ridge ending abruptly at both extremities; process of the third joint (fig. 1, *b*, *d*) distinctly articulated, fourth joint short; sensoria of the funicle numerous, only shortly free distally, those on the inner aspect of the fifth joint being slightly broader than any others; spinose bristles on the inner surface of the pedicel (fig. 1 *d*) numerous and stout.

Trophi. Mandible with two small teeth and swollen along the anterior edge; its ventral surface with about five ridges. Appendage (2 : 1) short and broad, three-fourths as long as the mandible itself and half as broad, with five ridges. Stipes with one lateral bristle and no free splint.

Thorax. Protergum broadly concave posteriorly; free striated margin broad, narrower at the extremities; whole sclerite bristly—40 bristles, more or less, on each side of the mid line. Scutellum generally with three bristles along each furrow and 7–8 (minute) across the middle. Propodeon (fig. 1, *e*) with numerous bristles round the spiracle. Prepectus showing a number (6–8) of fine striae, antero-posteriorly directed, on the outer two-thirds. Mainly posteriorly, the mesosternum bears numerous bristles.

Forewings twice as long as broad, length about 1·125 mm. Submarginal : marginal : radius : postmarginal veins approximately in ratio 33 : 9 : 11 : 14. The

submarginal bears towards the base a clear pustule (before which 1–2 bristles may occur) without a bristle, but followed by five moderately long bristles, all on the proximal two-thirds of the vein. At the uprise to the marginal is one somewhat long

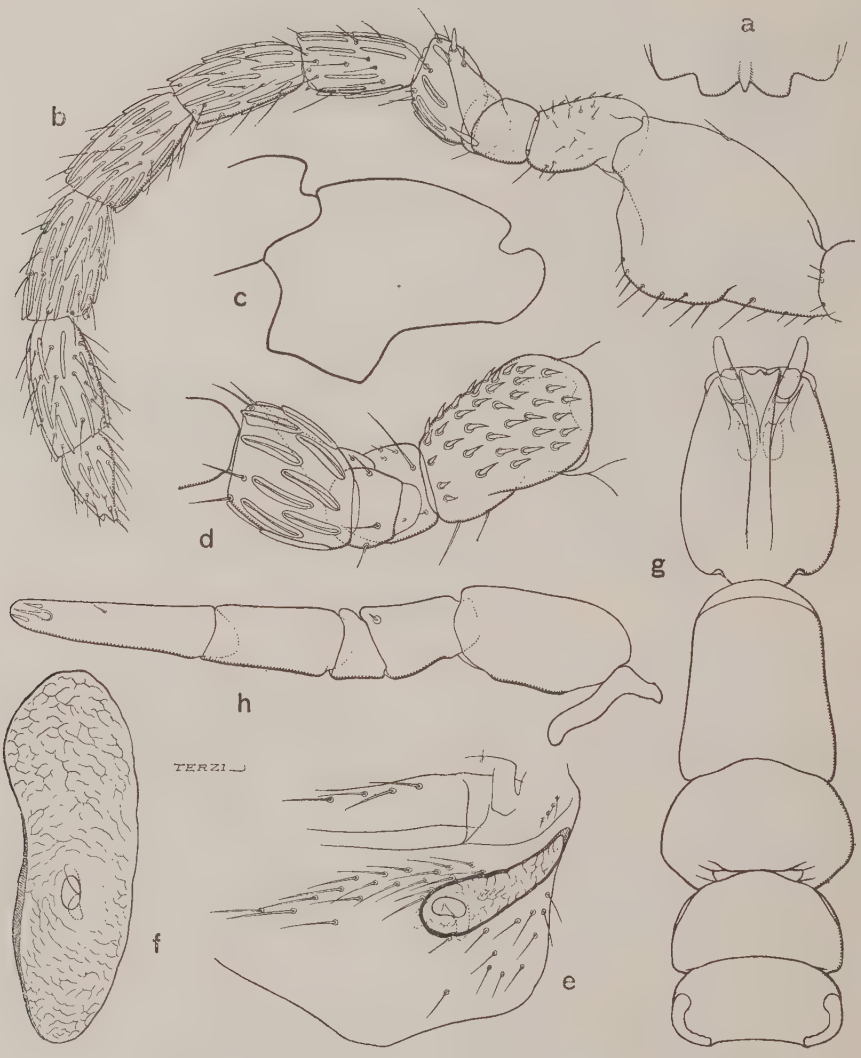


Fig. 1. *Ceratosolen hewitti*, Waterst. sp. n., ♀ : *a*, edge of clypeus ; *b*, antenna ; *c*, outline of scape to show ventral lobe ; *d*, armature of 2nd joint of antenna (pedicel), and details of joints 3 and 4 ; *e*, right half of metanotum and propodeon ; *f*, abdominal spiracle.
*C hewitti* ♂ : *g*, head and thorax ; *h*, antenna.

bristle and 3–4 clear pustules triangularly arranged. Up to the radius the marginal bears 7–8 bristles and the postmarginal 3–4 ; along the combined edges of marginal

and postmarginal stand about 20 bristles, some of which are double, *i.e.*, one rising from above and the other from below the membrane. Radius with 4–5 bristles and three clear pustules. Hindwing (7 : 2) 0·66 mm. long.

Legs. Fore coxa shorter (3 : 4) than femur ; the latter (12 : 5) much longer (8 : 3) than the tibia, which bears four teeth (alternately long and short) at the antero-dorsal apical angle ; tarsus approximately 4 : 2 : 2 : 2 : 5, the first joint with 2–3 bristles along the dorsal edge. Mid femur (4 : 1) longer (9 : 8) than coxa and trochanter combined, with four longish bristles in a median row anteriorly and 1–2 more, nearer the dorsal edge, apically ; posteriorly there are 8–9 bristles, mainly on the apical two-thirds, 4–5 as on the anterior aspect being in a median row, with the others above, towards the dorsal edge. Tibia distinctly longer than femur, narrow (10 : 1) on proximal two-thirds of its length, then rather abruptly expanding to the apex (7 : 1) ; along the dorsal edge are about 14 bristles (of which five or six on the apical third are longer), and one or two fewer on the ventral edge ; additional bristles occur distally on both faces, so that the apical third of the tibia is distinctly bristly. Tarsus longer than the tibia, its first two joints in ratio 11 : 7. Hind coxa externally naked, but with about a dozen short bristles on inner surface—mainly on dorsal half ; femur (2 : 1) not much longer (10 : 9) than coxa ; tibia (12 : 5) rather broad towards apex. Tarsus with first joint twice the second in length ; chaetotaxy of first joint, dorsal 7–8, anterior 12–13, ventral (plantar) 10—all beyond basal third—posterior 8–9 bristles ; those on anterior aspect the thinnest ; second joint 3–4, 8–9, 5–6, 5 ; third joint 2, 6, 4, 3. The plantar spines are stout and rise from definite sockets, the plantar edge not being frayed or fimbriated.

Abdomen. Tergites entire. The first (third) tergite bears over 30 minute bristles, and the spiracle is enormous (fig. 1, *f*). Ovipositor barely projecting beyond the apex of the abdomen. The length visible varies, according to pressure and relaxation of the parts, from 0·04–07 mm. in a series of mounted examples. The last sternite is truncated, except for a long, narrow median projection. Stylet (8 : 3).

Length, 1·5–1·9 mm. ; alar expanse, 2·8–3·4 mm.

♂.—Head length 0·45 mm. ; length of pronotum 0·35 mm. ; mesonotum length 0·23 mm., breadth 0·4 mm ; metanotum, length 0·175 mm., breadth 0·35 mm. ; propodeon, length 0·175 mm., breadth 0·35 mm.

Head (fig. 1, *g*) twice as long as broad anteriorly and about one-third longer than its maximum breadth. The bristles (1, 1) set just above the median lobe of the clypeus are short—half as long as their basal distance apart. Antenna (fig. 1, *h*) with bulla about four-fifths the length of the scape (11 : 6) ; pedicel (4 : 3) two-thirds of the scape. Funicle (three joints) twice as long as the scape, its first joint triangular in profile ; fourth joint shorter (6 : 7) than fifth, but both greater than the pedicel, which is only five-ninths of the fifth.

The propodeon is remarkably broad posteriorly (fig. 1, *g*).

Legs. Fore femur over twice as long as broad and more than two and one-third times the tibia (excluding the apical tooth) in length ; tibia longer (10 : 7) than the tarsus and not equal to the greatest breadth of the femur. Mid coxa, femur, tibia, and tarsus subequal—the coxa very slightly the longest ; femur very convex dorsally and subangulate at one-third from the apex ; apex of tibia with two teeth at upper angle, one laterally and externally and two ventrally. Hind coxa (2 : 1), or with membranous flange (10 : 7), shorter (10 : 11) than femur (4 : 3) ; tibia (5 : 2) not quite three-quarters the length of the femur and as long as the tarsus, bearing 4–5 teeth apically—counting both sides ; tarsus sparsely set with bristles, one (lateral and preapical) on joints 1–4 being longer.

Length, up to about 2 mm.

*Type* ♀ in the British Museum, one of a series of ♂ ♂ and ♀ ♀ from a fruiting trunk of *Ficus* sp.

BORNEO: Sarawak, vii. 1907 (*J. Hewitt*).

*C. hewitti*, sp. n., belongs to the group of which *C. striatus*, Mayr, and *C. crassitarsus*, Mayr, may be taken as representatives. It is at once known in the ♀ by the short ovipositor and the terminal segments of the funicle, while the ♂ is equally characterised by the head and propodeon.

## Genus **Eupristina**, Saunders.

**Eupristina verticillata**, sp. nov.

♀.—Head wider than deep (11 : 10); clypeus with a fine median ridge and distinct but not prominent oral lobes, each with one bristle. The antennal grooves, above the toruli, occupy about one-third of the width of the frons. Trophi: mandibles apically bidentate, with about five ventral ridges (fig. 3, *a*), anterior edge much swollen; appendage narrow, with 8–10 ridges (fig. 3, *a*, $a^1$) of which 2–3 near the articulation are strong, projecting tooth-like at the inner edge; maxillae (fig. 3, *b*) with no free splint. Antenna (fig. 2) just over 0·5 mm. long; pedicel with a number

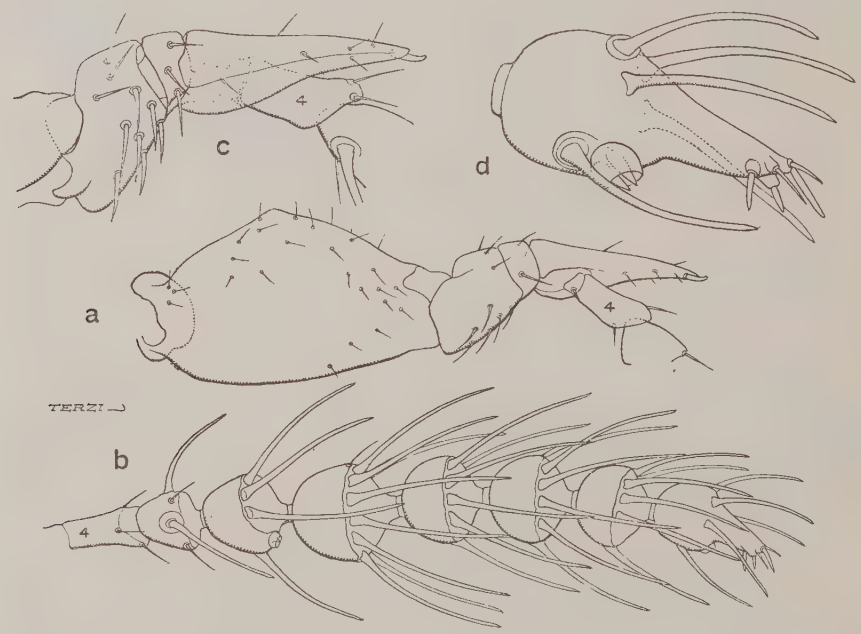


Fig. 2. *Eupristina verticillata*, Waterst., sp. n., ♀: *a*, *b*, antenna; *c*, detail of joints 2–4; *d*, apical sense-organs.

of stiff, rather fine, recurved bristles on inner dorsal aspect (fig. 2, *c*); process or appendage of third joint long, completely articulated; sense-organs on joints 5–11 long and tubular, subapical in position; besides these on the outer apical edge of the sixth joint a small cup-shaped sensorium with a short central process (fig. 2, *b*), and another much larger one on the basal half of the eleventh joint (fig. 2 *b*, *d*); at the extreme apex of the club a group of sensory spines—five in all (fig. 2, *d*).

Thorax. Pronotum entire, but with a deep concave membranous area anteriorly; posterior edge gently and evenly concave, the free striate margin expanded abruptly at the extreme sides into a subtriangular head; spiracle not greatly salient. Medianly and anteriorly the sclerite is bare, but at each side posteriorly towards the expansion of the striate margin are 6–7 short bristles in two rows, and about a dozen more round the spiracle. Scutum bare, except for one minute bristle on each side near the furrow at one-third before the suture. Parapsides with six bristles. Scutellum and meso-

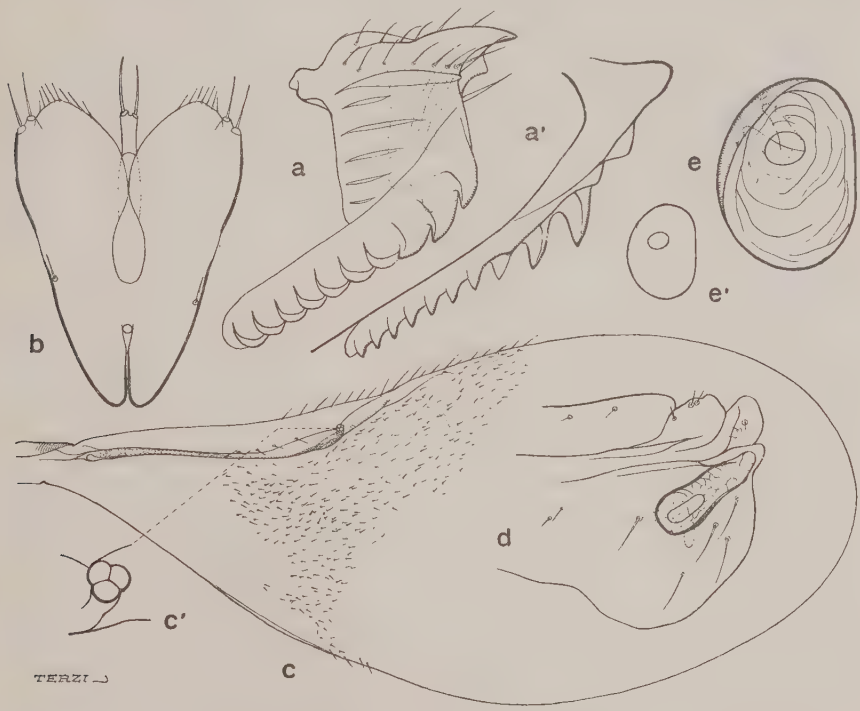


Fig. 3. *Eupristina verticillata*, Waterst., sp. n., ♀ : *a*, mandible, ventral view; $a^1$, mandible in profile; *b*, 1st and 2nd maxillae; *c*, wing; $c^1$, pustules on submarginal vein; *d*, right half metanotum and propodeon; *e*, abdominal spiracle; $e^1$, the same, on same scale as *d*.

sternum each with bristles 3–4 : 3–4. Propodeon (fig. 3, *d*) with four moderate bristles beyond the spiracle and one (occasionally two) minute near the posterior end of the spiracle on the inner (admedian) aspect. Metasternum intumescent on each side of the mid line, its surface raised in minute chitinous points.

Forewing (fig. 3, *c*, $c^1$) just over 1 mm. in length, two and a quarter times as long as broad, bare on about the basal fourth.

Legs. Fore coxa (2 : 1) with a longitudinal row of about 24 long bristles, which form a fringe on inner aspect; femur (17 : 8) about one-third longer than the coxa; tibia over twice as long as broad and equalling in length the breadth of the femur, bearing at the apex antero-dorsally two teeth, with ventrally a short chitinous projection with one spinose bristle above; both anteriorly and posteriorly the tibia bears a lateral row of about four short stiff bristles, and there are a few more along the

dorsal edge ; tarsus 2, 1, 1, 1, 3 ; the first joint bears one dorsal subapical bristle, one anterior, one ventral, and three (stouter) posteriorly ; joints 2–5 have bristles 1, 1, 2, 1, while five bears 1, 1, 0, 1. Mid coxa much widened posteriorly ; femur (10 : 3) shorter (6 : 7) than tibia (barely 6 : 1), which has about eight short stiff bristles along the dorsal edge and four ventrally on apical third. Tarsus as long as tibia, each joint with one subapical bristle dorsally and another apically and ventrally ; joints in ratio, 8, 7 : 7 : 5 : 9. Hind coxa (7 : 4) with 5–7 short heavy spinose bristles ; femur (2 : 1) one-seventh longer than the coxa ; tibia (3 : 1) three-fourths of the coxa in length ; tarsal joints in ratio 15 : 9 : 7 : 6 : 11.

Abdomen. The tergites from the second (fourth) onwards are deeply incised postero-medianly up to about one-half of their length. Between the spiracles is a broadish membranous area, and this tergite is produced anteriorly into a broad, angularly rounded median lobe. The stylet (8 : 5) bears four bristles—three apically and one at the side. The ovipositor sheath is slightly dilated apically, the ovipositor extending beyond the apex of the abdomen a distance of about 0·6 mm. The spiracle (fig. 3, *e*, $e^1$, same scale as *d*) is oval, flattened on one side.

Length (excluding ovipositor) 1·4 mm. ; alar expanse, 2·4 mm.

*Type* ♀ in the British Museum, one of a small series of ♀♀ " From large tree with small figs in middle of Museum grounds."

Borneo : Kuching, Sarawak, xi.,1907 (*J. Hewitt*).

*E. verticillata*, sp. n., is an isolated form which I have placed in this genus with some reluctance. It is easily recognised by its antennae, wings, protergum, etc. The material available for description is in a very broken condition, there being only two complete antennae and one wing in a score of specimens. Such dealation and loss of appendages are commonly incurred when the female enters the fig in which the eggs are to be laid.

The neuration of the single wing preserved is peculiar and perhaps abnormal. There is a distinct marginal and postmarginal length, and in the membrane itself a disconnected pellucid thickening, suggesting an obsolescent radius. Particular attention is for this reason directed to fig. 3, *c*, which illustrates the points referred to.

# THE BIONOMICS OF *TABANUS APREPES*, AND OTHER AUSTRALIAN TABANIDAE.

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(Plates I and II.)

During recent years the number of described species of Australian Tabanidae, or March-flies, as they are almost universally called in this country, has been increased very considerably, and with this increase there has come a wider knowledge of the distribution of the various genera and species. While advancement has taken place in this direction, little progress appears to have been made towards acquiring an accurate knowledge of the life-history and habits of any of these flies, and, up to the present time, no precise information has been published concerning oviposition, larval development, feeding habits and pupation of any of our numerous species.

In this paper I propose to describe in some detail the life-history, habits and developmental stages of *Tabanus aprepes*, Taylor, and *T. rufinotatus*, Bigot, which have been reared from egg to adult, and to discuss other species so far as present knowledge permits.

**Tabanus aprepes,** Tayl.

*T. aprepes*, Taylor, Proc. Linn. Soc. N.S.W. xliv, p. 56.

*T. batchelori*, Taylor, *loc. cit.* p. 58.

*Distribution.* This species is recorded from South Queensland (Eidsvold), North Queensland (Townsville and Kuranda), and the Northern Territory (Darwin and Batchelor).

*Breeding-places.* The following notes are based on observations made during the period 18th October 1919 to September 1920, in three localities within the municipal boundaries of Townsville, namely, (1) a small permanent rock-hole and stream arising from it, situated within half a mile of the Institute building, (2) a small shallow swamp about 250 yards distant from the rock-hole, and (3) a group of similar swamps on the outskirts of the town.

During the wet season and for some months afterwards the rock-hole and adjoining pools and riffles (Plates I and II, fig. i.) are completely swept by a rapid torrent of surface and soakage water from adjacent land; but later, when the flow is reduced to a regular and steady trickle, there is present a plentiful supply of algal growth and three or four feet of clear water in the rock-hole and rather less in the pools. From June to December 1919 the moist banks were searched unsuccessfully for larvae and pupae resulting from eggs deposited during the previous summer. On 10th October 1919 and later, Tabanidae were occasionally seen flying about, or momentarily resting upon the heads of children playing on the sea beach distant about 300 yards from the rock-hole—then the only locality within a mile or more from which they could have emerged. The species could not be determined with certainty, but was provisionally referred to *T. aprepes*.

More frequent visits were now paid to the locality in the hope of definitely associating with it the flies occasionally noticed in the vicinity. Digging operations were undertaken wherever the soil was sufficiently moist or loose enough to permit of the emergence of the flies from the ground; then the harder and drier parts of the bank and neighbouring soil were dug over and sifted, the rocks and herbage overhanging the water were searched frequently for ovipositing females or their eggs, and a few

horses and cows which drank at the lower pools were watched, but no evidence of TABANIDAE could be found until 6th January, or two days after the first heavy fall of rain (106 points) since the preceding March.

On 6th January a female *T. aprepes* was observed on a twig about four and a half feet over the water (Plate I), apparently about to oviposit, when she was disturbed by a spider and flew off.

On 13th January three egg-masses were found on the same twig, all of which appeared to have hatched, but on removal to the laboratory three living larvae were rescued from a spider's web which enveloped one end of one mass. Although there appeared to be no unhatched eggs in the masses, the latter were placed over water, and during the night 110 larvae were produced, some of which were subsequently reared to the fly stage and identified as *T. aprepes*.

From 16th January until 16th April numerous larvae of *T. aprepes* were found in the algae floating on the surface of the water. Heavy floods swept the holes in the locality during the month of April, after which larvae were not found.

On 2nd April a female *T. aprepes* was observed to alight on the twig from which eggs were taken on the 13th January, and the process of oviposition was observed, with the aid of a magnifying glass, from commencement to conclusion, when the fly was captured and the eggs removed to the laboratory, where larvae were subsequently reared.

Of the 39 egg-masses collected here (Locality 1) between 13th January and 9th April, five were found on twigs and six on grass leaves or seed-heads overhanging water in the rock-hole (Plate I), the majority being from 3 to 4½ feet above the surface; three were found on grass leaves a few inches above the water trickling from the rock-hole, and 25 on the terminal shoots of couch-grass overhanging a sloping bank (Plate II), the surface of which was oozing with soakage water and algal growth.

The adjacent swamp (Locality 2) dried early in July 1919, and remained in this condition until 4th January 1920. Towards the end of April 1920 the surface area reached its maximum, there being then about 4½ feet of water in the deepest parts. Repeated searches were made for egg-masses on plants overhanging the margin and on lily and other leaves floating on the surface, but none were found. During these searches numerous half-grown to full-grown larvae (*T. aprepes*) were found clinging to the lower surface of the lily leaves, or to the stems, or hidden in floating masses of algae, from 20 to 30 yards from the margin and in from 3½ to 4½ feet of water. A few of these larvae were bred to maturity to confirm identifications.

The small lily-pond (Locality 3, Plate II, fig. 2) dried late in July 1919, and remained so until 4th January 1920. In May of 1919, when the water was two or three feet deep, a careful search was made for Tabanid larvae amongst the reeds and water-lilies, but none were found.

From 10th June 1919 onwards, the banks of this and adjoining ponds were examined from time to time as they dried, but in none of them were the larvae or pupae of *T. aprepes* found, although other species were taken.

From January 9th to April 16th 1920, when the ponds and swamps contained water, egg-masses and larvae were unsuccessfully sought for on many occasions. On the latter date a careful search was made of the vegetation growing near the banks and of the lily leaves in deeper water (4–5 feet) with the result that many larvae of *T. aprepes*, in all stages of development, were captured. On the same date a fly of this species was observed ovipositing (1.45 p.m.) on the underside of a seed capsule of a plant growing in eight inches of water and twelve inches from the bank. When about 30 eggs had been laid, a lamp chimney, closed at one end with mosquito netting, was slipped over fly and plant and tightly plugged with wadding. The stem was then cut off about an inch below the wadding plug, leaving the

fly and eggs practically undisturbed. In this position the chimney and its contents were returned to the water and overhanging plants. Several times during the next hour the fly appeared to be on the point of continuing oviposition, but each time returned to the netting without having extruded any eggs.

Between 21st and 25th April very heavy falls of rain and high winds caused an accumulation of drift (grass, aquatic plants, twigs, cow and horse dung, etc.) to be thrown up on the sloping banks of this and adjacent pools. When examined on 28th April, numerous half-grown to full-grown larvae of *T. aprepes*, *T. rufinotatus* and *T. nigritarsis* were found in the drift and on or under the soil beneath it; while others were found buried in the grass-covered soil between the outer fringe of the drift and the foot of a stiff loamy bank three or four feet from it (Plate II, fig. 2). The latter were full-grown and were in some cases obviously at rest in the positions in which they intended to pass through the long dry period to follow; in others they were still burrowing downward. Quite a number of those found in the drift, and especially in that part near the water's edge, were evidently feeding, as shown by the contents of the alimentary tract. Many of these larvae (*T. aprepes*) were captured and bred out in the laboratory in July and August.

While turning over the soil and drift on this date several recently discarded pupal cases were found and subsequently identified as those of *T. rufinotatus* and *T. nigritarsis*. These pupae were almost certainly the product of eggs laid more than a year earlier, since the unusual conditions of the 1919-20 season and the shortness of the possible breeding period (103 days) almost preclude the possibility of their being derived from eggs laid during the current year. No definite evidence has been obtained to determine the maximum period during which the larvae of these insects may remain in a dormant condition, but certain facts suggest that full-grown larvae may, after the usual long resting period and in the face of a drought, postpone their transformation into pupae for six months or more.

On the same date (28.iv.1920) and a few yards distant, full-grown larvae of *T. aprepes* were found making their way up a slope from the water's edge, through short wet grass and litter towards a bank (similar to that shown in Plate II, fig. 2) and about eight feet from the water's edge. Some were actually travelling when observed, others were sheltering in the grass or under debris.

These banks were examined four months later (30th August), when several *T. aprepes* (three pupae and five larvae) were found, and on the same afternoon an adult female was captured in the vicinity. The period (winter) intervening between these dates, 28th April–30th August, had been unusually mild and moist, doubtless favouring early development and rendering the emergence of the adults possible after even a light shower of rain. During the preceding year, owing to drought conditions, emergence of adult flies from this soil would have been a physical impossibility throughout the whole period April 1919 to January 1920.

*Oviposition.* In discussing breeding-places brief reference has been made to two flies which were observed in the act of ovipositing on 2nd and 16th April. As the process differed in several respects from that recorded for Indian and American species, it may be of interest to refer to it more fully here. At about 4.30 p.m. on 2nd April, whilst sitting by the water's edge (Locality 1), a fly was seen to alight on the underside of a twig about four feet above the surface of the pool (Plate I) and about three feet from my head. The twig lay at an angle of about 45° to the water, and the fly settled on it *head uppermost*. After lightly touching the surface of the twig many times with the tip of the abdomen, the first egg was extruded whilst only the extreme apex of the abdomen was flexed. Immediately the apex of the egg touched the twig it appeared to stick, and as it left the body it was forced out of the vertical position to an angle of about 20°; the apex of the abdomen was again applied to the twig at the point of attachment and to one side of the egg just laid and a second

extruded in the same manner. Three eggs were then laid close to and in front of the first two, each one as it left the ovipositor being pressed firmly against those behind, until the latter lay almost parallel to the twig. In this way three or four gradually widening rows were laid, each slightly nearer vertical than the preceding one. Then a second and similar tier was commenced on top of those already laid, the first row of eggs of the second tier resting on the second or third row of the lower tier. Moving her body slightly forward, the fly extended the lower tier two or three rows before continuing the upper tier. In this way the operation was continued until the mass had covered the lower side of the twig for a length of 30 mm., when the fly moved forward a few millimetres and remained stationary until captured. The rate of oviposition was about three eggs a minute, and at no time was the apex of the abdomen brought *under the thorax*, as stated by writers dealing with extra-Australian species.

*The Egg-mass.* The size and shape of the egg-masses are very variable. As a rule they are about 20-33 mm. long by about 2 mm. wide when deposited on slender twigs or narrow blades of grass, or they may be more compact when laid on seed-heads or other objects offering a wider base for the mass. The mass is invariably as wide as the object upon which it rests and generally contains two layers of eggs. Some of the masses, however, contain three layers of eggs and are proportionately shorter and higher. Sometimes a second and even third mass is laid very near to or overlapping part of an earlier one, and small masses containing only a few score of eggs are found near masses of average size. The number of eggs per mass probably averages about 500, but much smaller and much larger masses, *i.e.*, 250–700, are found. At first the mass is creamy, but in the course of about 24 hours it changes to light slate-purple, and gradually darkens with the development of the larvae. There is a complete absence of the white chalky substance used by some species as an outer coating of the mass, and more often than not its general appearance is distinctly rough and lacking finish.

Fig. 1. *Tabanus aprepes*, Tayl., eggs.

Fig. 2. *T. aprepes*, embryo 78 hours old.

*The Egg.* The eggs measure 1·60 mm. to 1·65 mm. in length, by 0·3 mm. in width, and are variable in shape according to their position in the mass, but always bluntly rounded at either end (fig. 1). The surface is smooth and glossy and, in recently laid eggs, pearly white. The colour changes rapidly; eggs that were laid at 1.50 p.m. on 16th April changed to grey by 5.15 p.m., to dark slate-purple by 9.30 a.m. on 18th, and hatched during the night of 22nd or early morning of 23rd. Another batch of eggs which was laid at 4.30 p.m. on 2nd April changed to dark slate-purple by 9.30 a.m. on 4th and hatched between 2 and 4 p.m. on 8th. The egg period therefore was from six and a quarter days to seven days in the one case and about six days in the other.

For at least 24 hours before the young larvae hatch they are distinctly visible through the clear, thin shell (fig. 2). During this period they are active, dark-banded little creatures, with the head always directed outwards from the point of attachment

of the egg-mass. When about to liberate themselves the blade-like process (egg-cutter) at the anterior end is pressed against the apex and drawn downwards along the side in two or three deliberate strokes, which cause a rent in the shell sufficiently large to permit the young larva to escape rapidly.

*Larval Development.* Generally speaking, there is only an interval of a few minutes between the appearance of the first and last larvae from a given batch of eggs. Sometimes, however, the interval is much longer, and this is especially the case with large masses, in which, owing to their form, many of the eggs are concealed beneath tiers of other eggs. One large mass from which all the larvae had apparently emerged before noon (13th January) produced 110 additional larvae before 9 a.m. on the following morning; another produced about 600 larvae during the morning and 30 more late in the afternoon.

In only one instance (5th April) was the dispersal of larvae observed under natural conditions. On this occasion several very small larvae were gathered on the surface of the pool (Plate I) in one dip of the scoop while searching for *Anopheles*, and upon examining some twigs overhead an egg-mass was found from which larvae were then dropping. The mass contained approximately 300 eggs, arranged in a single layer eight or ten abreast, of which number about one-third had already hatched and dropped into the water; the balance emerged during the succeeding five or six minutes. Upon reaching the water the young larvae were rather sluggish, but sufficiently active to disperse by slow lashing movements, some remaining on the surface film, others seeking the shelter of floating masses of algae. Some of these larvae were collected and removed to the laboratory for examination and observation.

In the laboratory the egg-masses were usually suspended over a shallow dish of clean water, into which the young larvae dropped as they freed themselves from the mass. For some hours they remained more or less quiescent on the surface, during which period the first moult was accomplished. This process commences before, or immediately after, the young larvae leave the egg, and is sufficiently advanced to be seen under a low power five minutes later. Apparently the first moult is always completed during the first six hours of larval life. As a number of larvae from one egg-mass have been reared through all their stages to the perfect fly, the development of these may be now recorded. While this batch was under observation a number of other batches were available for study, and they supplied much information and material for examination which could not have been obtained from the constantly decreasing ranks of the original batch.

The egg-mass from which the larvae were obtained was found partly evacuated on 13th January (Locality 1); 110 young larvae emerged from it on the afternoon and night of 13th–14th January and 105 of these comprised the original batch.

*First Instar.* An accurate description of the young larva soon after it emerges from the egg is somewhat difficult, owing to the fact that ecdysis has already commenced. When about five minutes old and after fixation in the usual way the young larva measures about 1·40 mm. long by 0·28 mm. wide at the sixth segment; the segments appear to be withdrawn into each other; the cuticle about to be cast off envelopes the body loosely, excepting at the head, where it is firmly attached. The surface is pale in colour and distinctly marked with longitudinal striae; several moderately long slender hairs are present about the middle of each segment; there are no short spine-like hairs fringing the anterior margin of the first three segments (thoracic), such as occur on the fourth segment and in increasing numbers on the fifth to the tenth segments. The anterior margin of the first two segments and the anterior and posterior margins of the following seven segments appear to be banded, but this appearance is due to characters on the cuticle beneath. The mandibles are withdrawn into the head, but in cleared specimens they are seen to be short, curved rods arising apparently in the anterior third of the first segment. The egg-breaker

is a black, chitinous, angular projection of the upper anterior margin of the labrum and is the most conspicuous feature of the first instar. Graber's organ is visible on the posterior portion of the tenth segment as a pair of dark, pyriform, closely approximated bodies.

*Second Instar.* Since most of the characters found in the larvae of the second instar are visible through the cuticle of, and appear to belong to, the first instar, the changes which follow the first ecdysis do not appear to be so great as they are in reality. Fixation in hot alcohol after the first ecdysis is completed and in all subsequent stages of larval development has the usual effect of extending the body to its fullest length ; thus, whereas the length of a larva of the first instar is about 1·40 mm., the length just after moulting is about 1·00 mm. greater. The measurements, descriptions and figures which follow are all from specimens fixed in hot 70 per cent. alcohol, and therefore fully extended. The characters of the larvae of the second instar are shown in fig. 3, which represents a larva between one and six hours old. Such larvae range

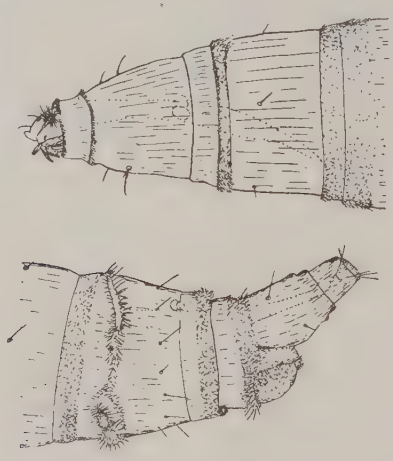

Fig. 3. *T. aprepes*, anterior end of larva 1–6 hours old (above) ; posterior end of same (below).

from 2·35 mm. to 2·63 mm. in length, by 0·375 mm. to 0·425 mm. in width at the widest part ; the segments bear distinct longitudinal striae ; the anterior border of each segment, excepting the first three (thoracic), is fringed with numerous small bristle-like hairs and dense short brown pile, which produce the banded effect (segments four to nine inclusive resemble the tenth segment shown in fig. 3). The first three (thoracic) segments are shown in fig. 3. The mouth-parts are prominent ; the first maxillae, palpi, and antennae are easily distinguished ; the anterior projection of the labrum is rounded and no longer black and chitinous ; four malpighian tubes are distinguishable ; Graber's organ still contains one pair of bodies, which are now seen to be enclosed in a pyriform sac, the rounded end of which is foremost ; the apical third of the syphon tube bears two groups of three long slender hairs, which usually appear to arise at the extremity owing to invagination of the apex and withdrawal of the stigmal plate.

During the 16 or 17 hours following the first ecdysis there is little apparent change in the young larva other than a slight increase in size and, generally, the addition of another pair of bodies in Graber's organ. A long series of larvae of this age measured from 2·35 mm. to 2·82 mm. in length, by 0·35 mm. to 0·425 mm. at the widest part.

For about three days following their emergence the young larvae do not feed, but remain on the surface film. After this period, however, they commence to attack each other, even in the presence of an abundant supply of small shells and other animal life introduced upon aquatic plants.

When twelve to fourteen days old the majority of the larvae measured from 6 mm. to 7 mm. in length, by 0·7 mm. to 0·85 mm. in width; the groups of hairs on the syphon tube increased to four or five, and Graber's organ contained either two or three pairs of bodies, each pair diminishing in size from the anterior end. A few of the larvae had developed very slowly during these twelve days and now measured only 4·5 mm. in length. In two larvae (7 mm. and 8·5 mm. in length respectively) a second pair of mandibles could be distinguished in the anterior third of the first segment, and faint traces of the dark bands characteristic of older larvae of this species could be detected near the junction of the segments and near the anal protuberance. The second ecdysis apparently takes place when the larva is between 7 mm. and 9 mm. in length. Unfortunately the number of larvae in this batch became so reduced, largely owing to cannibal practices, that specimens could not be secured as frequently as desired to determine this point, but a " wild " larva captured on 2nd March appeared to represent an early stage of the third instar and to connect the last-described individuals with older and more advanced ones of the same batch. This larva measured 9 mm. in length by 1·5 mm. at the widest part; the junctions of the segments were banded and blotched with dark brown, and the dorsal tubercles and the pseudopods bore short bristle-like hairs, as in older larvae.

On 2nd March, or when 49 days old, two larvae of the original batch measured 15 mm. and 16 mm. in length respectively. Whether the subsequent changes in the larvae follow ecdyses, or whether they are developed gradually during the third instar, has not yet been satisfactorily determined. On 16th April, or when 94 days old, two other larvae of this batch were destroyed by their fellows. The former now measured 21·5 and 24 mm. long by 3 and 4 mm. wide respectively. The brown bands and blotches are now very distinct and of the same pattern as in adult larvae; the striae are well marked on all segments, but are absent on the brown areas; the mandibles are black; the bunches of stout curved spines above the insertion of the antennae are pale ferruginous, very prominent, and overhang what appear to be moderately large facetted eyes situated behind them; in the smaller of the two larvae there are five pair of bodies in Graber's organ, in the larger six pairs; the stigmal plate is now visible at the apex of the syphon tube. About the anterior third of the first segment (prothoracic) there are several long branched hairs, on other segments they are simple or absent; the pseudopods are prominent; there are no hairs on the anterior margin of the thoracic segments, these being confined to the dorsal ridges and pseudopods of the abdominal segments, where they are inconspicuous. The dark bands and blotches are formed entirely of very short and dense pile, as in the younger larvae; the pseudopods were very prominent in the larger of the two larvae.

On the same date (16th April) the contents of the breeding-tray were collected, with the object of separating the remaining larvae of *T. aprepes* and several larvae of *T. nigritarsis* which had been placed in the tray recently. The former now numbered only five, two of which measured about 28 mm. long and three about 33 mm. long. One of the latter was retained for examination and is described below, the others were put separately into five-inch flower-pots half full of moist, clean granite sand, upon which lily leaves and shells were placed every three or four days. The larva referred to above was 94 days old at the time of its death, and measured 33 mm. in length and 5 mm. in width. In size and coloration, as well as in external form, it so closely resembles the mature larva which has undergone a long resting period that a description of it will suffice for both. There are six prominent pseudopods to each segment from the fourth to the tenth inclusive, arranged on the anterior margin, three on each side of the median line; each pseudopod is armed with a number of short bristle-like hairs; on the dorsal surface of the same segments there are two transverse

tubercles situated on the anterior margin on either side of the median line, which appear to be of the same nature as the pseudopods and similarly armed. The dorsal surface is blotched and banded boldly with dark brown (fig. 5), the pattern of which is very characteristic and constant. The ventral surface of segments four to nine inclusive are creamy white; from the dark anterior margin of the first segment

Fig. 4. *T. aprepes*, adult larva, lateral view.

Fig. 5. *T. aprepes*, adult larva, dorsal view.

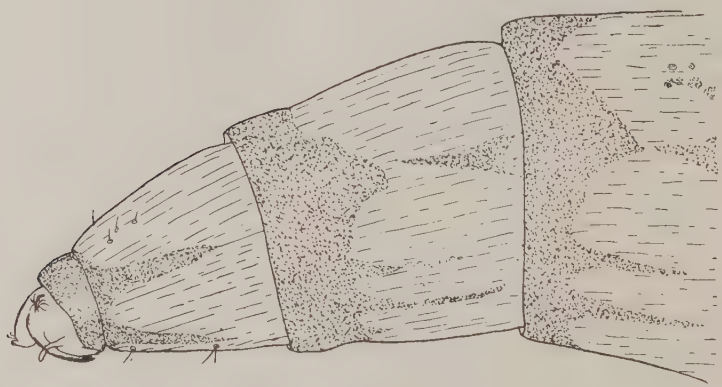

Fig. 6. *T. aprepes*, adult larva, anterior end.

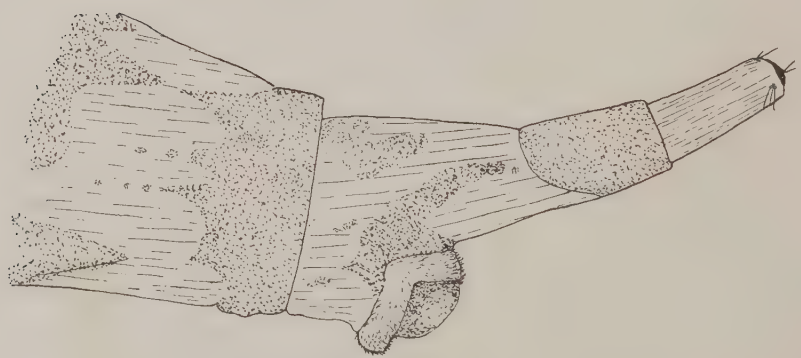

Fig. 7. *T. aprepes*, adult larva, posterior end.

(prothoracic) there extend posteriorly five dark, lanceolate marks, one on either side of the dorsal and ventral surfaces, and one in the median line of the ventral surface. The second and third segments are banded anteriorly (fig. 6) and the tenth posteriorly (fig. 7) with brown.

As the larvae reached maturity and ceased to feed (about the third week in April) they were placed together again in a large receptacle containing moist sand, in which they remained for about two months. At first they were very active, coming to the surface at night and returning to the sand during the day, but never attacking each other. On 3rd June they were all in a torpid state and contracted to about 18 mm. in length, but when placed in water they regained their normal appearance and activity.

On 25th June one of the larvae, now 164 days old, pupated in a vertical position four inches below the surface and after a pupal period of 11 days emerged as a perfect fly (female). Another larva pupated about a week later and was preserved as a specimen; the third pupated on the 7th July and produced a male fly on 21st July, or 190 days after hatching; the fourth remained in the larval stage until 8th September (239 days), when it was destroyed for examination.

*Larval Habits under Natural Conditions.* Under natural conditions the larvae are to be found commonly on or near the surface of clear and moderately deep pools, amongst submerged herbage near the banks, resting upon the lower surface of lily leaves, upon the submerged stems and leaves of all kinds of aquatic plants and in floating masses of algae. Clear and moderately deep water appears to be essential. The food of the young larvae is not known, but it is believed to be the small molluscs, which were fed successfully to larvae reared in captivity. Several kinds of molluscs are very plentiful in most of the breeding-places, and these certainly form an important part of the diet of older larvae, which have frequently been found feeding on them.

In the rock-hole (Locality 1) this food is absent, but there is a plentiful supply of other kinds. Cannibalism is common amongst "wild" larvae, and is practised by individuals in all stages of development. To give some idea of the voracy of these insects, it may be mentioned that on one occasion 12 large larvae were placed in a pickle-jar of water and algae for transportation to the laboratory—a journey of three miles—and upon arrival there only two remained alive, one of which destroyed the other before arrangements could be made for their separate accommodation. On another occasion over 50 nearly full-grown larvae were placed in a large porcelain dish with sand, water and fresh molluscs. Within four days many of the latter and 40 of the larvae were destroyed.

With the aid of a small stout wire net attached to the end of a long bamboo rod the plant growth can be disturbed sufficiently to dislodge the larvae, which, even if carried down by the currents thus created, soon appear near the surface and are easily captured in the net. In some cases a stout wire hook at the other end of the rod was found useful for dragging masses of vegetation towards the bank for closer inspection. Wading was resorted to in many cases, but the results were usually unsatisfactory on account of the restricted range of vision.

The larvae appear to live entirely in water until they have reached maturity, when they migrate from the water to high ground close by, as described elsewhere in this paper, and penetrate into the soil or clay to a depth of from 7–15 cm., where they remain in the larval stage, generally with head uppermost, for several months.

*The Pupa.* During the first few hours following metamorphosis the entire pupa is buckthorn-brown,* but the eyes soon deepen to mummy-brown, and then to blackish brown, while the thorax becomes argus-brown. The average size is about 21 mm. in length by 4 mm. in width at the thorax, the 1st and 6th segments slightly narrower than the 2nd to 5th inclusive.

On the dorsal surface of the first abdominal segment there are two stout hairs on either side of the median line and three on each pleura, two of which arise close together near the wing-sheaths. Segments 2 to 7, inclusive of both surfaces, bear an

* Ridgway's colour nomenclature.

uninterrupted fringe of long and short bristles arranged roughly in two rows, the shorter bristles nearer the base ; on each segment from the 2nd to 5th these bristles increase in length ; on the 5th, 6th and 7th they are equally long or, rarely, the long bristles may be absent from the middle of the seventh tergite and sternite and the shorter ones may be branched.

The six projecting spurs at the apex of the abdomen are arranged three on each lobe of a prominent bilobed tubercle divided vertically by a deep cleft, which is wider in the males ; the upper and middle pair are equally long and stout, the lower are smaller ; on either side of the dorsal surface midway between the base of the tubercle and the apex of the 7th segment there is a group of four or five stout spines of unequal length. The length and stoutness of these bristles vary greatly in individuals of either sex.

The anal tubercle is very large and deeply furrowed in the male and is bordered anteriorly by an unbroken fringe of about 18 to 22 stout bristles of variable lengths. In the female the fringe is broadly interrupted in the middle, and consists of from 6–9 bristles on either side (fig. 8).

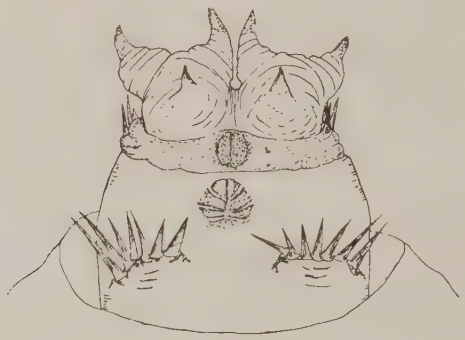

Fig. 8. *T. aprepes*, ventral surface of last segment of female pupa.

*Duration of the Pupal Stage.* The duration of the pupal period during the months June–September varied from 8 to 20 days, the average being 12 days in the case of 10 individuals whose periods were accurately observed.

The factors which determine early or late emergence of laboratory specimens are not known, and no explanation can be offered at present of the fact that whilst certain pupae of a batch pass through a very short pupal stage—*e.g.*, eight days—others of the same batch and subjected to the same treatment may remain in the stage for periods up to 20 days.

*Emergence of the Fly.* The emergence of laboratory-bred flies has been observed on several occasions—always between 10 a.m. and 4.30 p.m.—and in each the procedure was similar. The pupa, with its body vertical, works its way to the surface, from which it protrudes the thorax and first two or three abdominal segments. In this position it remains motionless for from one to two hours ; then, with very little apparent effort, the thorax is burst on the dorsal surface to the posterior margin of the mesothorax, and also along the lower margin of the eyes, leaving a flap-like piece bearing the anterior group of tubercles more or less loosely attached ventrally. The fly frees itself in a minute or two, leaving the greater part of the pupal case as before. At emergence the wings are uniformly opaque, but in the course of an hour or two they become hyaline or suffused with brown, as the case may be.

*The Adult.* The adults of this species show considerable variation in regard to size and coloration and, as might be expected, in laboratory-bred specimens this is more

apparent than in those bred under natural conditions. In a recent paper* it has been stated that the wings show various gradations in colour from a total absence of infuscation to a very pronounced shading, especially at the veins. A long series of males and females bred out in this laboratory show these gradations to a marked degree, not only in flies reared from full-grown larvae captured in natural surroundings, but also in flies reared from the same batch of eggs. Variations in abdominal coloration of both sexes, and especially in the females, is even more pronounced. In some specimens there are evident spots at the apex of certain segments, in others the abdomen is of uniform dark brown or uniform ochraceous tawny. In three wild females captured in June in this district the colour of the abdomen is so light as to lead the writers of the above-mentioned paper to refer them with some doubt to this species. Recently, however, a similar form has been bred from a batch of eggs which also produced individuals showing all the variations of wing and abdominal coloration. It would appear that in this and other species too much attention has been paid in the past to slight or even marked differences of this kind. When these variations in colour are associated with abrasions of the abdomen and thorax, and especially of the front, the possibilities of error in diagnosis are greatly increased unless a fairly long series is available for comparison.

In life the lower third and the lateral and posterior margin of the eyes of the male are claret-brown with emerald-green iridescence ; the upper two-thirds are drab grey and composed of coarse facets. In the female the facets are small throughout and the colour uniform drab grey with brown iridescence.

*Seasonal Occurrence.* Throughout Australia, perhaps excepting the wet belts of the North Queensland coast, of which I have little knowledge, there is a marked seasonal occurrence of flies of this family, namely from about October to April. In the southern regions, where there are regular winter rains and low winter temperatures, the emergence of flies is probably regulated by temperature and not by rainfall ; but in the north, where the temperature is more or less equable and the rainfall is, excepting for moderate falls, confined to the summer months above mentioned, the condition of the soil, whether dry or wet, is most certainly the regulating factor. Thus almost invariably the march-fly season is either early or late, good or bad (from the collector's point of view) according to whether the summer rain is early or late and normally heavy, light or absent.

The chief natural breeding-places in this district, and in most others with which I am familiar, are in temporary accumulations of water, such as shallow swamps, which disappear completely in the winter or dry season and after the full-grown larvae have entered the soil in the vicinity of the water's edge, wherever that may be at the time of their reaching maturity. As the soil dries these larvae are practically immobilised, and remain so until it again becomes thoroughly moistened. It follows, then, that there can be no emergence of flies until after heavy rain has fallen.

The truth of these statements has been demonstrated on many occasions, and notably during the summer of 1919–20, when until 4th January the country was in the grip of a severe drought, and there was an almost complete absence of Tabanids in this district. Heavy rains for a short period in this month were followed by the appearance of a moderate infestation of flies. (It may be stated here that the previous season also was one of unusually low rainfall, and therefore an unfavourable one for fly breeding.) The January rainfall was not sufficiently heavy to raise the level of the swamps to normal, and another long spell of dry weather intervened before the banks in the vicinity of the normal high-water marks were thoroughly saturated. About the middle of April abundant rains filled the swamps, and there followed a marked increase in the number of flies in the district. Whether the flies were derived from eggs laid in January 1920 or during the preceding wet season could not be

* Ferguson & Hill, in the press (Proc. Linn. Soc. N.S. Wales).

determined, but the period required for the life-cycle, as ascertained later, suggests strongly that the latter was more probable. Further, there is no evidence to suggest that the Tabanids in this or other districts known to me produce two generations in one season. Obviously these remarks do not apply to localities in which there is permanent surface water, such as Locality No. 1.

In some localities a few individuals of certain species, particularly *T. rufinotatus*, are to be found throughout the dry season (June to August), but their occurrence can be accounted for by the presence of permanent water (such as Locality No. 1), or at any rate marshland, in the vicinity.

During June of this year numerous young larvae were found in pools which dried a few weeks later. The question naturally arises whether these larvae perish or whether they are able to burrow into the mud to lie dormant through the remainder of the dry season and until conditions again become favourable for their development. Attempts to determine these questions have been unsuccessful, but it may be mentioned that one larva from a late batch of eggs was, when about 9 mm. long, accidentally isolated in the laboratory in a pot of dry sand and without food of any kind from about 6th June to 28th August. On the latter date it had the general appearance of adult larvae in the resting stage preceding pupation, and became active immediately it was placed in water containing suitable food and cover. Unfortunately neglect caused its death before any development could be detected. Hine, working in America, found that certain Tabanid larvae after a long resting period again fed before pupating, but nothing of the kind has been observed to take place in the case of any of the species studied here.

*Rearing Larvae in Captivity.* Various methods of rearing the young larvae were tried, but as none of them gave satisfactory results it is not intended to describe them in detail. In order to prevent cannibalism young larvae were isolated in small earthenware pots with a capacity of about 120 c.c., prepared in various ways, and supplied with various kinds of food. Apart from the difficulty of keeping the water in these vessels fresh, this method was found to be too cumbersome, and the larvae rarely survived for more than a week or so. Larger vessels, *i.e.*, five-inch flower-pots and small museum jars, were equally unsatisfactory. Kerosene tins cut lengthwise into two equal parts gave better results, and in them a few larvae were reared from the egg to maturity. These tins were prepared by placing a quantity of clean sand at one end and two or three inches of water at the other. Pieces of water-lily leaves, algae and swamp plants carrying small molluscs were placed in the water to afford shelter and food, and these were renewed as often as possible. The water was changed every four or five days by lifting one end of the tin and allowing it to filter through the sand. The tin was then partly filled and again emptied in this way, before being finally replenished with water and food-bearing vegetation. Each tin contained the progeny from one batch of eggs, *i.e.*, 300–600 larvae, of which never more than 1–2 per cent. reached the imago stage. When molluscs were not obtainable mosquito larvae and small earthworms were offered as substitutes, but worms were invariably refused by larvae in all stages of their development. Mosquito larvae were destroyed by the Tabanids when the former were stranded in algae or sand, but otherwise they appeared to have been able to avoid capture. At all times Tabanids of this species appear to feed upon their fellows in preference to molluscs or any other animals, and for this reason it was found best to transfer the survivors, when of nearly full size, to separate pots or dishes, where they completed the development in moist sand, upon which molluscs and portions of lily leaves were placed. The best results were obtained from a batch of 105 larvae which were reared in a concrete trough, measuring 16 inches wide by 20 inches long by 6 inches deep, prepared similarly to the tins just referred to. As the larvae approached maturity the water was gradually reduced until it was confined to a small area at one end of the trough. In this molluscs were placed every week or so, until

it was found that none were being devoured, when the water was drawn off and the trough half filled with clean sand, which was kept moist. From time to time the sand was turned over to watch the progress of development, but beyond this the larva received no attention for intervals of several weeks. Some of the larvae pupated and produced flies in this trough, but most of them were transferred to small pots of clean moist sand, where they completed their development. In future it is intended to use these large troughs or galvanized iron trays instead of the smaller vessels.

**Tabanus rufinotatus,** Big.

*T. rufinotatus*, Bigot, Mem. Soc. Zool. France, v, 1892, p. 673.

*T. lineatus*, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 65.

*T. elestëem*, Summers, Ann. Mag. Nat. Hist. (8) x, 1892, p. 224.

*T. designatus*, Ricardo, Res. Expéd. Sci. Néerlandaise Nouv. Guinée, ix, pt. 3, 1913, p. 390.

*Distribution.* This is a widely distributed species, having been recorded from South Australia, New South Wales, Queensland and the Northern Territory, and also from Dutch New Guinea. The South Australian specimens in the British Museum collection are most probably from Port Darwin (Northern Territory) or its vicinity, which prior to 1911 formed part of the state of South Australia.

*Breeding-places.* On 25th March 1919, an egg-mass was taken from the lower surface of a *Juncea* leaf growing three feet from the bank of a shallow water-hole (near Locality 3) in twelve inches of water. At the time the pool contained a maximum depth of three feet of water and was much frequented by cattle and horses which grazed in the district. As the season advanced the water dried back rapidly and finally disappeared before the end of May. During the period intervening between 25th March and 28th May 1919 the vegetation near the water and the muddy banks and bottom were searched for egg-masses and larvae respectively, but without success. During the same period and up to the present date (September 1920) many other possible breeding-places have been repeatedly examined, but so far only a few adult larvae have been secured.

*The Egg-mass.* The egg-mass referred to above, from which the larvae described in the following notes were derived, measured 5·5 mm. in length by 4·25 mm. in width at the base and 3·5 mm. in height. The eggs, which numbered about 500, were arranged very compactly in three tiers and were coated, either separately or collectively, with a white secretion. After the larvae hatched, the mass retained its form so perfectly that, viewed from any direction but from above, it appeared to be still composed of viable eggs.

*Larval Development.* The larvae hatched almost simultaneously at noon on 30th March and moulted between that hour and 9 a.m. on the following day. Specimens were not secured prior to ecdysis, so that the first instar cannot be described here.

*The Second Instar* (figs. 9, 10). When 24 hours old the larvae of the second instar measured from 2·5 mm. to 2·6 mm. in length by about 0·25 mm. in width at the widest part. Up to this age they were of uniform size, but at the end of the second day variations became apparent, some measuring 3 mm., while others had increased to 3·5 mm. The cuticle is creamy white and bears minute longitudinal striae; the tufts at the base of the antennae are short and many of the component hairs are forked; the prothoracic segment is short, and the hairs which fringe its anterior margin and the anterior margin of the next segment are difficult to discern. The dorsal tubercles and pseudopods are armed with moderately large hairs, and each segment bears several isolated long, slender, pale hairs.

The young larvae remained in a small dish of water for three days without food, when they were placed in a large concrete trough containing sand at one end and

water at the other. In this they were offered small molluscs, young mosquito larvae and small aquatic animals that adhered to the water-lily leaves used to provide cover. From time to time dead larvae were found which appeared to have been destroyed by their fellows, but the remainder seemed to thrive. On 10th June, or when 77 days old, one of the larvae measured 15 mm. in length. Unfortunately this specimen was lost before a detailed description was obtained. On 3rd July the sand was allowed to dry off gradually, and from this date onwards small earthworms only were offered as food. On 8th October the sand was washed over, but no larvae were found. The vessel and its contents were left undisturbed until 27th October, when the now dry sand was sifted, yielding three larvae measuring from 22 mm. to 23 mm. in length by about 2·5 mm. in width. In such larvae the cuticle is glossy and devoid of the striae observed in larvae of the second instar, there is no trace of banding, and the hairs on the dorsal tubercles and pseudopods are colourless.

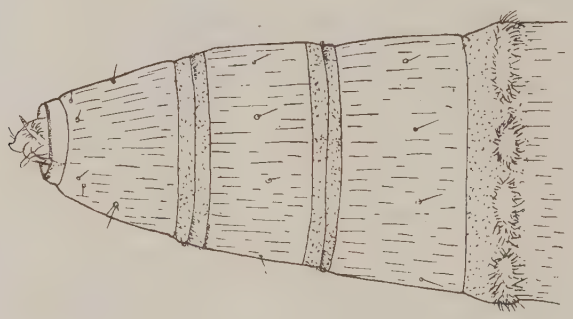

Fig. 9. *Tabanus rufinotatus*, Big., anterior end of larva 24–48 hours old.

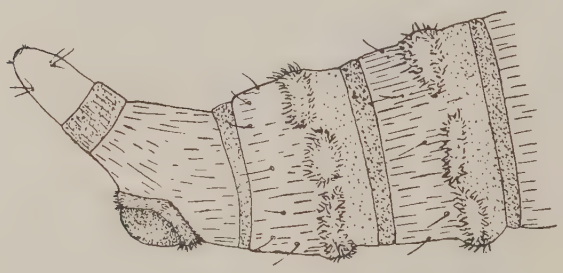

Fig. 10. *T. rufinotatus*, posterior end of larva 24–48 hours old.

The two remaining larvae were now placed in a large shallow dish, containing sand at one end and water at the other, in which they were fed on earthworms and mosquito larvae until 8th November, when they were placed separately in five-inch flower-pots standing in a dish of water and containing three inches of clean sand. On 8th December both larvae were evidently fully grown. One of these was secured for examination and is described below, the other was returned to its pot, to which had been added a few small earthworms and a little earth. A week later it was found dead and damaged beyond recognition by scores of nematode worms. The loss of the sole surviving larva rendered the identification of the species with which I had been dealing for over nine months impossible for the time being, but the larvae secured on 27th October

and 8th December provided the material from which a determination was subsequently made in comparison with a series of " wild " larvae, some of which were subsequently bred out.

*The Adult Larva* (figs. 11, 12). The full-grown larvae measure from 26 to 29 mm. in length by about 4 mm. in width, and are creamy white in colour, with the faintest indication of darker bands ; the cuticle is glabrous and without striae ; the tufts at the base of the antennae are composed of short stout hairs ; there are no hairs on the anterior margin of the thoracic segments, and those of the dorsal tubercles and pseudopods are very short, slender and dark in colour.

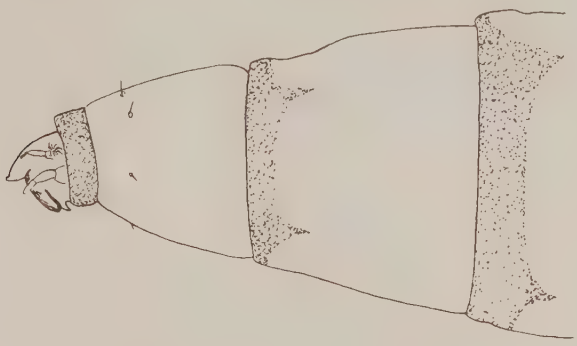

Fig. 11. *T. rufinotatus*, anterior end of adult larva.

Fig. 12. *T. rufinotatus*, posterior end of adult larva.

From this record it will be seen that under laboratory conditions the larval stage was not less than eight and a half months.

*Development of Larvae under Natural Conditions.* Larvae were taken on 28th April 1920 in association with the larvae of *T. aprepes* and *T. nigritarsis* (see notes on *T. aprepes*), and again in a similar bank on 15th June in association with the larvae of *Silvius notatus*. After securing specimens for examination, the remainder were placed in small earthenware vessels containing sand, which were thereafter kept moist. The flies emerged as follows : —one female on 23rd May (after a pupal period of nine days), one male on 2nd June, and one female on 21st July.

*The Pupa.* The average length of the pupa is about 15 mm. and the width at the thorax about 4 mm. The eyes are blackish ; the vertex (in the female) and thorax Dresden brown, the latter with faint traces of stripes ; abdomen ochraceous tawny, with Dresden brown stripes corresponding to the black stripes on the abdomen of the

imago. The first abdominal segment bears two isolated hairs on either side of the median line and one on each pleura behind the spiracle; the second to seventh tergites and pleurites each have a double row of bristles, those of the anterior row being much shorter than those of the posterior. On the ventral surface, segments 2, 3 and 4 each bear an irregular single row of bristles of varying length; on the 5th to 7th segments the bristles are arranged in two rows; the terminal segment bears the usual number of large spurs (six); anterior to the anal tubercle there is, in the male, a fringe of about twenty long straight or curved bristles, which in the female is interrupted in the middle and is composed of five to eight stout and generally straight bristles (fig. 13). In the male the anal tubercle is large and deeply ribbed, in the female it is small but prominent. On either side of the dorsal surface, midway between the base of the upper pair of spurs and the posterior margin of the 7th segment, there is a group of six or eight stout bristles of irregular size and shape, which in the female is reduced to two or three much smaller bristles; in addition, in the male, there is on either side a group of two or three very short bristles midway between the above and the posterior extremity of the anterior fringe.

Fig. 13. *T. rufinotatus*, ventral surface of last segment of female pupa.

*The Adult.* In life the eyes of the male have the upper part grey, with deep brown iridescence, and the lower part, lateral and hind margins maroon, with an emerald-green band in line with the insertion of the antennae. The facets of the lower part are larger than those of the upper. In the female the eyes are maroon to dark maroon-purple, with two broad green bands in line with the callus and subcallus respectively.

*Seasonal Occurrence.* These flies were very scarce indeed during the period February 1919 to September 1920. Females were seen or captured in the field in the months of January, February, April, June, September and December, generally while buzzing about one's head or resting upon one's hat. Horses (locally and in the Northern Territory) appear to be more troubled than cattle, the former usually being bitten about the nose, ears, rump and coronet.

**Tabanus nigritarsis,** Tayl.

*T. nigritarsis,* Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 67.

*Distribution.* This species has been recorded previously from North Queensland (Houghton River) and the Northern Territory (Darwin, Stapleton, etc.).

*Breeding-places and Habits.* Between the 19th May and 10th June 1919 five apparently full-grown larvae were gathered from the submerged stems or leaves of

various plants growing in a few feet of water at the margin of a small swamp (Locality No. 3, Plate II) and removed to a concrete trough containing a pile of sand at one end and water at the other. In this vessel they were fed upon molluscs until 3rd July, after which date food was refused by them. The water was now drained off and the sand allowed to dry gradually until only the bottom two inches remained moist, in which condition it was kept for about four months. On 19th August one of the larvae was found in a vertical position about three inches below the surface of the sand. The body was then much contracted, but when placed on the surface the insect became more or less active and extended its length to about 25 mm. This specimen was allowed to bury itself again, and remained undisturbed in the sand until 8th October, when it and two other larvae were found in the above condition. One of these was preserved in the usual way and is described in these notes; the others were placed separately in five-inch flower-pots full of sand and imbedded in the sand contained in the larger vessel, where the two remaining larvae of the original batch of five were presumed to be resting. The two larvae in pots remained very active, but refused to eat either molluscs or earthworms, although they came to the surface almost nightly until 18th November. On 26th November one of these larvae was found undergoing metamorphosis, the other following on the morning of 1st December (11 a.m.), the former producing a female fly on 12th December and the latter a male on 17th December (between 9 and 10 a.m.).

On 27th November the sand in the large trough was sifted and another larva secured, which pupated on 12th December (5 p.m.) and produced a female fly on 28th December. The fifth larva was not recovered and was, therefore, presumed to have been destroyed by its fellows during the early days of their captivity. From the foregoing it will be seen that the pupal period in the laboratory was 16-17 days. Throughout the greater part of their lives in captivity these larvae and pupae showed much restlessness, and in the latter days of their pupal existence frequently wriggled to the surface or projected the posterior end above it, proceedings which would have been impossible under natural conditions owing to the hardness of the soil in which they would have been embedded.

As previously noted (under *T. aprepes*) a few larvae of this species were found in the resting stage in a clayey bank in this locality on 25th April 1920, associated with *T. aprepes* and *T. rufinotatus*. On 15th June following five additional specimens of *T. nigritarsis* were taken under similar conditions in the same locality. At the time of writing (30th September 1920) the majority of these are still in the larval stage in moist sand, others which at the time of capture were embedded in balls or tubes of plastic clay and placed on the laboratory shelves to dry were equally healthy and active when released on 30th September.

*The Larva.* The adult larva measures about 35 mm. in length by 5·5 mm. in width and is cream-coloured, faintly blotched and banded with yellow ochre (figs. 14–17). The pseudopods are arranged two on either side of the median line on the ventral surface and one on each pleura, these and the dorsal tubercles being only slightly elevated. The surface of the cuticle is dull and distinctly marked with longitudinal striae, except where banded or blotched.

*The Pupa.* The pupa measures about 23 mm. in length by 4 mm. across the thorax and 5 mm. across the abdomen at the widest part. The eyes are blackish brown, the thorax slightly lighter and the abdomen argus-brown. The first abdominal segment bears two slender hairs on either side of the median line, one on each pleuron behind the spiracle, and two closely approximated hairs on the ventral surface near the margin of the wing-sheaths. On the dorsal surface of the 2nd segment there is a double row of bristles, the anterior row short, stout and of irregular size, the posterior much longer; the 3rd segment is similar to the 2nd; on the 4th, 5th and 6th the bristles increase in size gradually from the 4th posteriorly; on the 7th there are fewer long bristles in the posterior row, their place being occupied by others of intermediate size.

On the pleurae the armature is similar to that of the dorsum, except on the 7th segment, which resembles the ventral surface. On the ventral surface the 1st, 2nd and 3rd segments bear a single row of mixed short and long bristles increasing in length from the 2nd; the 5th and 6th segments resemble the corresponding segments of the

Fig. 14. *Tabanus nigritarsis*, Tayl., adult larva, lateral view.

Fig. 15. *T. nigritarsis*, adult larva, dorsal view.

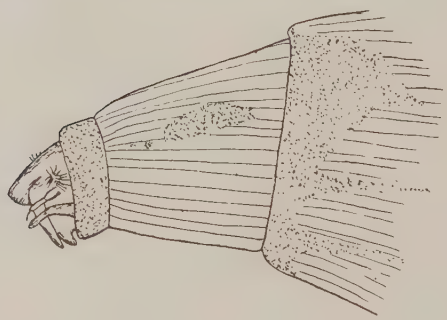

Fig. 16. *T. nigritarsis*, anterior end of adult larva.

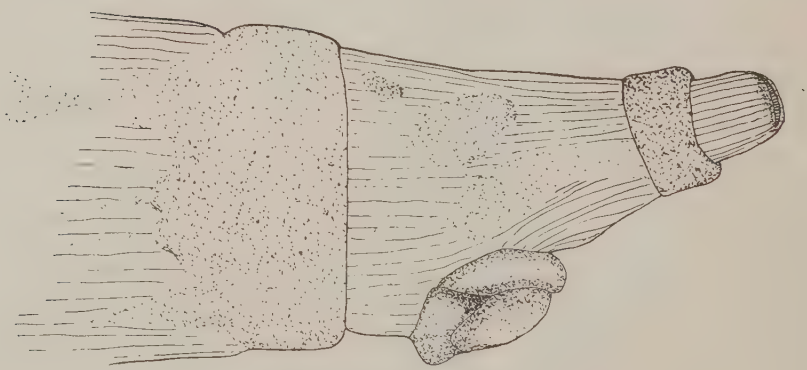

Fig. 17. *T. nigritarsis*, posterior end of adult larva.

dorsum, the 7th is similar, but has some short bristles in the posterior row. The integument of both surfaces bears transverse striae on the anterior two-thirds of each segment, which are generally absent or replaced by punctures on the posterior third. The armature of the terminal segment is variable. In most specimens there

is on the dorso-lateral margins, and midway between the base of the second pair of projecting spurs and the posterior margin of the 7th abdominal segment, a well-developed group of from five to seven very irregular bristles arising from a raised base. In some specimens these bristles are reduced to three or four in number, and in one they are absent on one side and on the other represented by two rudimentary bristles. In the male the anal opening is bordered anteriorly by a semicircle of stout and very irregular bristles, some of which are expanded and branched at the base, others short and almost rudimentary, or all may be long and moderately slender. Posteriorly the opening is bordered by a raised and deeply furrowed prominence. In the female (fig. 18) the fringe of bristles in front of the anal opening is broadly interrupted in the middle, each group being composed of from five to eight bristles of variable size.

*The Adult.* In life the eyes of the male are dull yellow-green and coarsely facetted above the point of junction of the eyes on the front; below this and on the sides and posterior margin the facets are smaller and bronze-coloured, with gold and green iridescence. In the females the eyes are uniformly dull yellow-green.

Fig. 18. *T. nigritarsis*, ventral surface of last segment of female pupa.

*Seasonal Occurrence.* Apart from the three flies reared in the laboratory only two individuals (females) have come under my notice during the period 25th February 1919 to 30th September 1920. Both were captured whilst attacking horses during the last week in February of this year. In the Northern Territory (1912–1917) this species was regarded as the most numerous and most troublesome to stock during the months of December-February. The egg-masses found there were small and compact and were generally placed on the underside of pandanus leaves overhanging water.

**Silvius notatus,** Ric.

*S. notatus*, Ricardo, Ann, Mag. Nat. Hist. (8) xvi, 1915, p. 264.

*S. psarophanes*, Taylor, Proc. Linn. Soc. N.S.W. xlii, 1917, p. 520.

*S. fuliginosus*, Taylor, *op. cit.* xl, 1915, p. 810.

*Distribution.* This Tabanid is a widely distributed species, having been recorded from S.W. Australia, Victoria, New South Wales, South Queensland, North Queensland and the Northern Territory (*S. fuliginosus*, Taylor).

Although so widely distributed, it would appear to be a rare species in this district, where, apart from those referred to above, only one specimen (the type of *S. psarophanes*) has been recorded hitherto. Nothing is known of its early stages and the feeding habits of the larvae and adults.

*Breeding-places and Habits.* On 22nd August 1919, while breaking down and sifting the low banks of a small lily-covered pool (Locality No. 3) about 24 Tabanid larvae were found in nearly dry, stiff, loamy soil at depths below the surface varying from 10 to 30 cm. In most cases the larvae lay in a vertical position with the head uppermost, others lay horizontally, and a few vertically with the head downward. At the time the bank was distant 12 feet from the water's edge and six feet from the mud which intervened between it and more or less dry soil. All the larvae were in the lower part of the bank in soil which had been above water-level since about 12th May, and although a search was made in the mud and adjacent dry soil no larvae were found there. The undamaged larvae, 16 in number, were removed to the laboratory and placed in two five-inch flower-pots containing moist soil, in which they remained undisturbed until 8th October. From the 22nd August until 22nd September they were very restless and wandered over the surface of the soil at night. These movements ceased on the latter date, and on the 8th October about one inch of the surface soil in one pot was temporarily removed, exposing the head and thorax of three pupae. The colour of the eyes and wing-sheaths indicated that they were then from about three to five days old. The oldest was preserved as a specimen, and the others were placed separately in pots of earth, from which they emerged as flies (♂ and ♀) on 13th October after a pupal period of about eight days. On the same date two males emerged from the second pot. Other flies emerged as follows:—1 ♂ on 25th October, 1 ♂ on 3rd November, 1 ♀ on 8th November, 1 ♂ on 24th November, 1 ♀ on 26th November, 1 ♀ 30th November, 1 ♂ 2nd December (pupal period 14 days), 1 ♀ 12th December.

On 15th June 1920 two resting larvae were taken from the bank shown in Plate II, fig. 2, and were transferred to small pots of sand, where they still remain in the larval stage (30th September).

*The Larva.* The adult larva measures about 33 mm. long by 4 mm. wide and is of a creamy white colour with narrow orange citrine bands at the anterior end of each of the first ten segments. On the first three segments the banding is obscure and on the 11th it is confined to a collar-like expansion of the posterior margin. Each abdominal segment, excepting the last, bears a slightly elevated transverse ridge or tubercle about half as wide as the segment, as well as a pseudopod on either lateral margin and a pair of pseudopods on the ventral surface. Macroscopically the dorsal and ventral surfaces are similar in appearance. The integument is glabrous and bears very distinct longitudinal striae. The first and last segments, and especially the spiracle (figs. 19, 20), differ greatly from those of any species of the genus *Tabanus* known to me. Grabner's organ has not been made out.

*The Pupa.* The pupa measures from 18–20 mm. in length, 3–3·5 mm. in width across the thorax, and 3·5–4·0 mm. across the widest part of the abdomen. The colour varies, according to age, from chestnut-brown to mars brown, head and apices of wing-sheaths blackish brown, lower surface and sides of first abdominal segment ochraceous tawny. In the male the head is as wide as the thorax, in the female slightly less. The abdomen is nearly cylindrical in both sexes. The thoracic spiracles are large and overlap the posterior margin of the head. The first abdominal segment bears two slender hairs on the tergite and one on each pleurite near the wing-sheath. The second tergite bears an interrupted single row of very short stout and irregular bristles and three or four long bristles, generally towards the sides. The third, fourth

and fifth tergites are similar, except that the bristles are stouter and there are about eight long bristles on each. On the sixth and seventh tergites the bristles are fewer and stouter than on the preceding ones. On the pleura they are arranged roughly in two rows, those in front being much shorter and fewer than those behind. Sternites 2–7 are armed similarly to their corresponding pleurites. On the anterior half of each tergite there are five or six small dark-coloured depressions, the foremost being nearest the pleura and the hindmost nearest the median line. Behind the anterior margin of each segment and parallel with it there is another row of three or four similar depressions on either side of the median line. The anterior two-thirds of each tergite, pleurite and sternite are distinctly marked with transverse striae ; posterior to the bristles these striae are less distinct or absent and the whole surface is punctate.

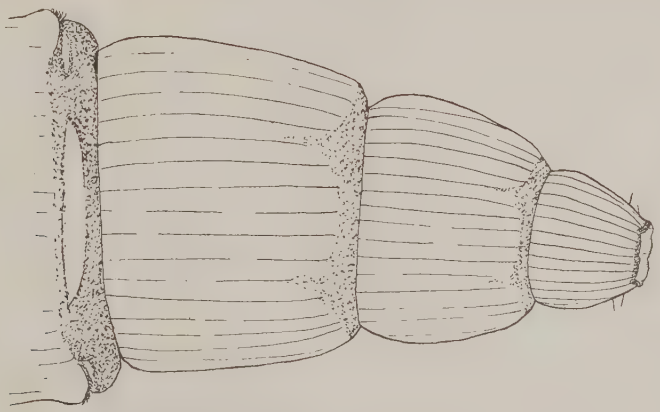

Fig. 19. *Silvius notatus*, Ric., anterior end of adult larva.

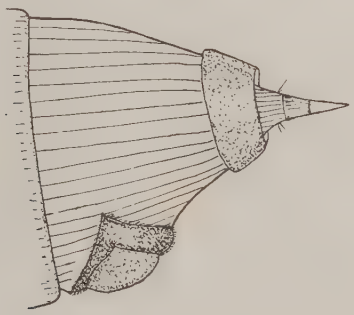

Fig. 20. *Silvius notatus*, posterior end of adult larva.

The terminal segment is deeply rugose, the two upper projecting spurs or bristles are parallel along their inner margins in the female and divergent in the male ; the middle pair is much larger than the upper and lower and projects laterally. The anal tubercle of the male is very large and deeply furrowed ; in front it is bounded by a continuous fringe of bristles, four or five comparatively small ones in the middle and a group of four or five very stout ones on each side, similar to but larger than

those of the female (fig. 21); the latter group of bristles is continued, with a slight interruption, around the sides of the segment to a point in line with the base of the lower pair of spurs. The size and number of these bristles are variable in both sexes, but are generally largest and fewest in the males.

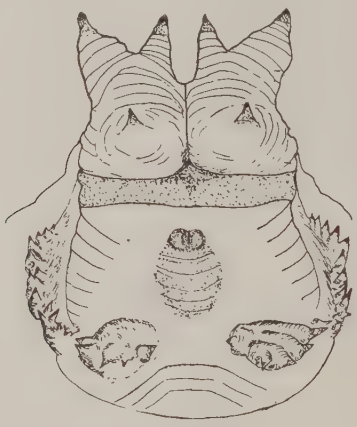

Fig. 21. *Silvius notatus*, ventral surface of last segment of female pupa.

*The Adult.* In life the eyes of the female are of uniform light seal-brown and the facets of equal size throughout. In the male the greater part of the surface of the eye is of the same colour, but at the lower third it is crossed by a sinuous, iridescent blue-green and copper band, which extends to near the lateral margins and is continued (in light seal-brown) around the posterior margin to the vertex. The facets forming this band are very small, while the remainder are large.

Rock-hole (Locality No. 1), showing spot upon which eggs of *Tabanus aprepes*, Tayl., were laid (marked with a cross).

Fig. 1. Pool in stream (Locality No. 1); twenty-five egg-masses of *Tabanus aprepes* were found on grass overhanging the bank.

Fig. 2. Clay bank (Locality No. 3) from which larvæ of *Tabanus aprepes*, *T. rufinotatus*, *T. nigritarsis* and *Silvius notatus* were obtained.

# THE LIFE-HISTORY OF *EUTHYRRHINUS MEDITABUNDUS*, FABR., AN IMPORTANT WEEVIL PEST OF MANGO TREES IN AUSTRALIA.

By G. F. Hill, F.E.S.

(Plate III.)

The adults of the weevil, *Euthyrrhinus meditabundus*, Fabr., were frequently taken in the forest country to the south of Darwin, Northern Territory, and on several occasions they were bred from the branches of two species of indigenous trees and from custard apples, Poincianas and two unidentified species of introduced ornamental trees growing in the Darwin Botanic Gardens. As a rule the infestation of these trees was not heavy, although Poincianas occasionally showed considerable injury. Mango trees, which were frequently badly damaged and sometimes destroyed by termites (*Mastotermes darwinensis*), appeared to be immune from attack by *Euthyrrhinus*, even when growing in close proximity to infested trees of other kinds.

Later, while a resident of Townsville, North Queensland, I had opportunities of studying the habits of this insect in the rôle of a mango pest of the first importance. Although these trees are not grown extensively for commercial purposes, they are to be found in many North Queensland gardens, where they are prized not only for their shade and beauty, but also for their prolific crops of fruit.

The following notes are the result of observations made on a number of large mango trees growing in the vicinity of the Australian Institute of Tropical Medicine, Townsville. In March 1919, two trees in particular attracted attention owing to the number of dead twigs appearing through the dense foliage at the summit, and although a close examination was not made then, the condition was attributed to the effects of drought during the preceding dry season. During the dry season of 1919 (April to the end of December) the condition of these trees gradually became worse, and others in the vicinity showed symptoms of disease. Early in this year (1920) one tree threw out bunches of leafy shoots along the main and upper branches, but the older foliage continued to fall. At the end of April this tree died, and of the other there remained alive only one secondary branch and a strip of bark extending from it to the ground. From that month (April) to the end of August the beetles emerged in great numbers from the trunks and main branches. Those beetles which emerged from the now dead tree migrated at once, presumably to living trees in the vicinity, while those from the other gathered on, and oviposited in, the remaining living portion.

Upon emerging from their holes the beetles are very active and begin at once to seek mates. The act of copulation occupies about ten minutes, after which the male remains attached to the female for some considerable time—two or three hours in some cases. During copulation the females, and afterwards both sexes, gnaw away the outer weathered surface of the bark and feed upon the living tissues or sap beneath, leaving small areas of exposed tissue to mark the feeding places. This injury is negligible, even when many beetles are confined in close captivity to a small area of bark.

## Oviposition.

The average period of development of the embryo within the ovary has not yet been satisfactorily determined. On 6th August a pair were observed copulating at noon, and an hour later they were removed to a healthy mango tree, on which they were enclosed in a small wire-gauze cage tacked to the bark. During the following three

days the male was generally found clinging to the female, but copulation was not again observed. The male died on the sixth day, and on the eighth day the female was seen to have the proboscis deeply buried in the tissues of the bark, apparently engaged in preparing a hole in which to insert an egg. Later in the day she was attacked and crippled by small ants (*Pheidole megacephala*). On the following day she was dissected, and an egg was found in the oviduct. Later two batches of six couples each were confined on the bark of the same tree in a similar manner. Most of the males died within ten days, and on 29th September there remained alive only one female of one batch and three of the other. On the latter date the cages and their contents were removed to fresh sites for further observation, and the bark previously covered by the cages was carefully examined for eggs or larvae. Although the surface showed numerous punctures, some of which extended to a depth of 3 mm., no trace of eggs or larvae could be found. The reason for this apparent delayed oviposition has not yet been determined, but it may be found to be due to refusal to oviposit in captivity even under conditions so closely simulating nature.

At noon on 8th September a wild female was observed with the proboscis inserted in the bark to a depth of about 3 mm. At 5.30 p.m. the hole was found to be plugged with comminuted bark, under which an egg lay 2 mm. from the surface. This egg was removed *in situ* to the laboratory, where it hatched 7 days later. About this time several other eggs were found in similar circumstances.

The egg is a rounded oval measuring 0·528 mm. in width by 0·688 mm. in length, pearly white in colour, with a very finely granulated surface.

### Larval Development.

Upon hatching the young larvae tunnel into the bark, subsequently, and while yet very small, boring into the sapwood, obliquely or horizontally at first, but always horizontally sooner or later. The duration of the larval and pupal stages has not yet been ascertained, but it is believed to total 12 months at least. Experiments designed to determine these points, and also the length of life of the perfect insects, are in progress.

### Appearance of Infested Trees.

The earliest observed symptoms of infestation are pronounced withering of the terminal twigs, followed by partial defoliation, the development of numerous adventitious tufts of foliage (Plate III), and the death of the secondary and, later, the main branches. The cause of these conditions is not manifest until the perfect insects begin to emerge from the dead or dying branches or, very rarely indeed, from branches in which there is still a flow of sap. As a rule the injury caused by the larvae is such that the branch is destroyed before the first beetles emerge.

The bark of a heavily infested branch will be seen to be pierced by numerous clean-cut holes (fig. 1) of various sizes, ranging from 1·5 mm. to 7 mm. in diameter, the smallest of which, *i.e.*, those up to about 2 mm. in diameter, are made by the adults of Hymenopterous parasites which have in the larval stage destroyed the young *Euthyrrhinus* larvae, the larger by adult weevils. The latter holes vary a good deal in size in accordance with variations in the size of the adults, *i.e.*, from 2 mm. to 6·5 mm. in width by 4·5 mm. to 12·5 mm. in length. The males are generally, if not always, very much smaller than the females ; but this statement appears to be often contradicted by the finding of pairs of approximately equal size in a copulatory attitude. If, however, these pairs are dissected they will be found to be females.

On the removal of the bark the sapwood shows a few shallow surface grooves made by the young larvae before commencing their drive towards the heartwood, but more often they bore straight in towards the centre without preliminary tunnelling. A large proportion of the young larvae fail to penetrate deeper than 5 or 6 mm. before

they are overcome by parasitic Chalcids. The survivors penetrate much deeper—*i.e.*, from 30–35 mm.—and when nearly full-grown turn about so as to direct the head outward. In this position they enlarge the burrow to one uniform diameter from its base to near the cambium, the frass accumulated in the process being very tightly packed behind so as to fill from 10–22 mm. of the burrow, in the remaining portion of which pupation takes place.

Fig. 1.—Main branch of a mango tree after the emergence of the weevils.

On emerging from the pupal stage the imago appears to undergo a rather long developmental stage within the pupal chamber, during which the body hardens and the insect becomes sexually mature.

The operation of boring its way out through the thin layer of sapwood and the bark which lies between the chamber and freedom is evidently a long and tedious process, judging by the notches worn on the sides of the hole by the leg joints of the toiling insect.

## Parasites.

Early in August, when the beetles were first noticed to be plentiful, a species of Chalcid wasp was frequently found in close association with them, or on adjacent foliage. Selecting a branch from which *Euthyrrhinus* were then emerging and which showed, in addition to their exit holes, a few smaller holes in the bark, two pieces, each about 2 feet in length, were sawn off and removed to a cage, where during the next few weeks about a dozen of the Chalcids emerged. On examination it was found that these insects had developed in holes about half an inch deep, which had been made by the young weevil larvae prior to being parasitised. Mr. A. P. Dodd, to whom specimens were submitted, informed me that, although known to him from the Cairns district, they belong to a new species, a description of which, under the name *Chalcis euthyrrhini*, appears below. A few weeks later several specimens of *Thaumasura curculionis*, Girault, were reared from the same branch and from the feeding-holes of young larvae of the same host. About the same time both parasites were also captured on

mango trees infested with *Euthyrrhinus*. It may be remarked here that the type and other specimens of *Thaumasura curculionis* were reared by me in Darwin (Northern Territory) from the branches of custard-apple trees and an undetermined introduced tree infested with *Euthyrrhinus meditabundus*. A third and somewhat similar Chalcid, of which a single specimen only has been secured, is also a parasite of this weevil. Mr. Dodd has identified this species as *Thaumasura pavo*, Girault. In addition to the above, two specimens of a much smaller parasitic wasp were bred from the eggs of this host, while a rather brightly hued Braconid has been taken frequently on infested branches. Although the latter has not been definitely associated with *E. meditabundus* as a parasite, there is little doubt as to its relationship with the latter.

It is only too evident that these parasites have not proved themselves to be of much practical value in controlling this pest, and that artificial means must be resorted to if efforts are to be made to prevent the destruction of these valuable shade and fruit-producing trees.

## Artificial Methods of Control.

No experimental work has been attempted with the object of devising means for combating the ravages of this insect, a pest which will probably prove difficult to control, and for several reasons. The adults are capable of flight as soon as they emerge from their burrows in the wood; and certainly disperse soon after emergence from trees which do not provide suitable conditions for rearing future broods. For this reason badly infested trees should be cut down and burnt before the adults leave them, for it is evident they cannot be saved once the main branches and trunks show evidence of heavy infestation. Whether the spread of the beetles from infested to healthy trees could be effectively checked by this means remains to be proved, but there is some evidence to suggest that such a measure would have the effect of localising the area affected.

Mango tree, showing effects of attack by a weevil,
*Euthyrrhinus meditabundus*, Fabr.

# A NEW CHALCID PARASITE OF *EUTHYRRHINUS MEDITABUNDUS*.

By Alan P. Dodd.

**Chalcis euthyrrhini,** sp. nov.

♀.—Length, 5–7 mm.

Head and thorax black; abdomen bright orange-red; tegulae red; antennae clear orange-red, the two apical club joints darker, the scape darker and varying to black; posterior legs, including the coxae, clear orange-red; anterior and intermediate coxae black, their femora and tibiae more or less brown or fuscous, their tarsi red.

*Head*, viewed from above, transverse, the occiput concave and (from lateral aspect) declivous, immargined; frons gently yet distinctly convex from eye to eye, viewed from in front distinctly wider than deep; antennal scrobes long, narrow, reaching to and hardly containing the median ocellus at base, divided by a wedge-shaped elevation that tapers to a point at half their length; eyes large, bare; ocelli large, in a slightly curved line, the lateral pair separated from the median ocellus by less than their own diameter; cheeks broad; surface with dense uniform umbilicate punctures. *Antennae* separated at base, inserted slightly above a line drawn across ventral end of the eyes, 13-jointed, counting the club as 3-jointed; scape slender, as long as the next four joints combined; pedicel not much longer than its greatest width; ring-joint large, narrowed at base; funicle 1 twice as long as its greatest width, 2 slightly longer than wide, 7 a little wider than long; club conical, fully twice as long as its greatest width, the first suture distinct and slightly before the middle, the second suture faint. *Thorax* normal, sculptured like the head, the sculpture very coarse, without conspicuous pubescence; pronotum large; its posterior margin deeply concave, the scutum thus much produced at meson anteriorly; anterior margin of scutum with dense scaly sculpture, rising sharply from the pronotum; scutellum hardly longer than its greatest width, its apical plate rounded; axillae rather widely separated; propodeon almost perpendicular in relation to the scutellum, moderately long, coarsely rugose and also finely shagreened, with a shallow median channel, laterally and near anterior margin with a distinct subacute tooth or projection on either side; pleurae sculptured like the rest of the thorax, the mesopleural depression longitudinally striate. *Forewings* ample, normal, stained yellowish, venation black; marginal vein three times as long as the stigmal, which is as long as the post-marginal. *Abdomen*, viewed from above, pointed ovate, fully twice as long as its greatest width, the valves of the ovipositor slightly exserted; gently convex above and beneath, no longer than the thorax; segment 2 (first body segment) almost as long as the others united, 3 longer than 4, 5 and 6 subequal and shortest, 7 fully as long as 4–6 combined, 8 rather short and with a median carina; 2 smooth and polished; 3–6 smooth, except for yellowish pubescence against their anterior margins, no setae at meson, the free area broader on 3, narrower on 6; 7 with rather dense shallow punctures and yellow pubescence; 8 pubescent. *Legs* normal; teeth on hind femora varying from eight to eleven, counting from base, 1 largest, 2 usually small and also usually the apical one or two.

♂.—Similar to the female, except that the pedicel is fuscous, also all the club and preceding joint; antennae as in the female, but the pedicel is smaller, the apical funicle joint is as long as wide, and the club is somewhat shorter; abdominal segments 5 and 6 comparatively longer, 7 shorter, the abdomen blunt at apex.

North Queensland: Cairns district and Townsville.

Described from two females and one male received from Mr. G. F. Hill, and a large number of females and one male collected by the author in January, March, May, September, October and November. Mr. Hill's specimens were bred from the Curculionid beetle, *Euthyrrhinus meditabundus*. Of the author's material, several

were bred from dead wood of the mango tree, and the remainder captured on dead or dying timber frequented by the same weevil ; it was found easy to collect a series by visiting the same tree for an extended period, one or more specimens being caught daily.

The host record is of considerable interest, inasmuch as the other members of the genus attack Lepidopterous and Dipterous larvae.

The diversity in habits of this species probably has some connection with the several minor structural differences. The convex frons, narrow antennal scrobes, concave occiput and produced scutum are peculiarities which might be given generic value, but a study of a series of species would need to be entered upon. The author has an unnamed species, collected in company with *Chalcis euthyrrhini* and probably with similar habits, which shows the same characteristics.

There is little variation in colour ; the abdomen and posterior legs remain constant, and the degree of variation in the first two pairs of legs and the antennae is not great.

Asymmetry in the femoral teeth is common ; there may be nine teeth on one femur and eleven on the other, or nine on one and ten on the other ; the femora of numerous specimens were examined.

*Type.* In the collection of the Queensland Museum, Brisbane.

*Cotypes.* In the collections of Mr. G. F. Hill and the author.

# MOSQUITO NOTES.—II.

By F. W. Edwards.

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**Anopheles flaviceps,** sp. nov.

*Head* with the integument rather light yellowish, especially when viewed from in front. Erect scales mostly brown, a small area of white ones in the middle towards the front, and in front of these a few long, narrow recumbent scales, not forming a definite frontal tuft. Many light brown bristles between the eyes; border bristles dark. *Antennae* with the basal joint yellow; in female with a few small scales on the second joint; male plumes light brown. *Female palpi* very slightly longer than the proboscis, thin, with appressed scales; narrow whitish rings at the tips of the first three joints, just extending on to the bases of the succeeding joints; tip of last joint dark. Second joint slightly longer than the first, slightly shorter than the third and fourth together; fourth joint less than half as long as the third. [*Male palpi* missing.] *Proboscis* dark, except for the labella.

*Thorax* rather light yellowish, darker in the females (perhaps through discoloration). Mesonotum somewhat shining, not darker at the sides, with light bristles, and in the middle with rather numerous, very narrow hair-like scales. Prothoracic lobes rounded, not mammillate, without scales. Prosternal hairs, five or six.

*Abdomen* light brown, with narrow dark bands in the male; hairs pale; no scales. *Male hypopygium*: Basal spines, five or six, all rather strong, in a loose, irregular cluster; one distinctly distal to the rest and much longer, but not more slender. Claspettes pointed; a long and fairly strong apical hair, half as long again as the club, which is normal in shape, but much more basally placed than the hair; no accessory hairs discernible. Tip of mesosome with about five rather narrow leaflets; the longest 0·55 as long as the mesosome.

*Legs* dark; extreme tips of femora and tibiae and extreme bases of tibiae pale; on the front and middle legs the tarsal articulations are also just perceptibly pale under a strong lens. All femora slender, cylindrical.

*Wings*: Costa dark on basal two-fifths, in one wing of one specimen with a small pale spot included near the base; apical three-fifths with four yellowish patches alternating with three dark ones, of which the third is the smallest, the first being distinctly larger than the adjacent light ones. A small dark spot at the wing-tip opposite apex of upper fork-cell. First vein light with four dark patches, the first being below the apical part of the dark basal two-fifths of the costa, the others below the remaining dark costal spots. Remainder of wing without conspicuous markings, but there are pale areas round the cross-veins, and the bases of the fork-cells, the base of the second vein, the middle half of the third vein, and the extreme tips of the second, third and fourth veins are also pale. Vein-scales linear, rather short and not very dense.

Anglo-Egyptian Sudan: Erkowit, 5.vi.1917, 1 ♂ (type), 1 ♀, also 1 ♀ from the same place, 22.v.17 (*H. H. King*).

*Type* in the British Museum, presented by the Imperial Bureau of Entomology.

Apparently most nearly allied to *A. turkhudi*, Liston, and *A. hispaniola*, Theo. (which may be a local form of *A. turkhudi*), but differing in the paler colour of the integument, especially of the head, almost obsolete frontal tuft, more numerous prosternal hairs, more shining mesonotum, and somewhat less conspicuous wing markings; also in the male hypopygium in the more pointed claspettes, which have no accessory hair and a more basally situated club, and in the stronger detached basal spine.

**Anopheles immaculatus,** Theobald.

Swellengrebel and Swellengrebel de Graaf have recently suggested (Bull. Ent. Res., xi, p. 78, 1920) that this may be an albinoid form of *A. vagus*, Dönitz. An examination of the hypopygium of a male from Java presented to the British Museum by Dr. Swellengrebel supports this possibility, since no tangible differences could be discovered between the hypopygia of the two forms.

**Anopheles leucosphyrus,** Dönitz.

Two rather well-marked forms of this species occur :—

(1) The typical form. Female palpi with the white rings distinct, the last joint white on at least its apical half. Proboscis of normal length, little, if any, longer than the palpi. Dark markings of wings less extensive ; the spots on the first longitudinal vein more broken up.

(2) Var. *hackeri*, nov. Female palpi with the white rings very narrow, the last joint white only at the extreme tip. Proboscis unusually long, longer than the palpi by almost, or quite, or even more than, the length of the last two palpal joints. Dark markings of wings more extensive ; the spots on the first longitudinal vein more fused.

The var. *hackeri* has recently been noted by Dr. H. P. Hacker (Fed. Malay States, Malaria Bureau Reports, ii, p. 33, 1921). A specimen collected by him and presented to the British Museum is designated as the type ; the Museum collection also contains a number of others from the Malay States, from Dr. Leicester's collection. The distinction in colour between the palpi of the two forms is quite sharp, and in length also it is very striking, but variable. Most specimens of the typical form have the palpi as described, almost, or quite, as long as the proboscis. However, among a small number from Borneo collected by Dr. Roper there is one which has an elongate proboscis like that of the dark form. Probably, therefore, the two forms are not specifically separable.

**Anopheles punctulatus,** Dönitz.

This species has recently been discussed by Swellengrebel and Swellengrebel de Graaf (Bull. Ent. Res., xi, p. 89, 1920), who concluded that it was not specifically distinct from *A. tesselatus*, Theo., and at the same time described a very similar form under the name *Nyssorhynchus annulipes* var. *moluccensis*. Finding that the description of *moluccensis* agreed rather closely with my conception of *punctulatus*, I wrote to Dr. Swellengrebel, suggesting that the two were the same, and received the following reply :—

" As to Dönitz's *punctulata*, there can be no doubt, judging from the published photograph, that its proboscis is white on the apical half. Moreover, the black ring near the apex of the second palpal joint is very narrow. This induced me to separate *moluccensis* from it, and I still think that the specimen from which the photograph was taken (probably the type) is a *tesselata*. As a general rule I believe it is well, from a practical point of view, to separate these allied forms, if, at least, a separation is practicable ; some of them may prove to be good carriers and others not (*rossii* and *ludlowi !*)."

After a close study of the literature and the British Museum collections, somewhat different conclusions seem to be indicated from those arrived at by Dr. Swellengrebel.

All the specimens in the Museum series of *A. punctulatus* prove to be practically identical with *moluccensis* in palpal markings, and most of them also agree in having the proboscis entirely black. One or two, however, including a specimen determined by Dönitz and coming from his type locality (Stephansort), show a pale area on the underside of the proboscis towards the tip. The colour of the proboscis cannot, therefore, always be used to separate *moluccensis* from *tesselatus*. I cannot agree

with Swellengrebel in placing *moluccensis* as a variety of *annulipes*; the latter, apart from its much larger size, shows some quite good differences in the wing-markings.

The three forms under consideration appear to be separable as follows (in the female sex):—

(1) *A. punctulatus*, Dönitz, typical form. Proboscis pale on the apical half, at least on the underside. Second joint of palpi about equal in length to the third and fourth together; its basal half black, and a narrow dark ring close to the tip of the white apical half. New Guinea.

There is no specimen exactly answering to this description in the British Museum, and Swellengrebel states that he has not met with it. Probably, therefore, Dönitz may have described and figured a somewhat aberrant specimen of the following.

(2) *A. punctulatus* var. *moluccensis* (Swellengrebel). Proboscis entirely black, or with a rather small pale area on the underside towards the tip. Second joint of palpi markedly longer than the third and fourth together; its basal three-fifths or more black, and a broader black ring towards the tip. New Guinea; Moluccas.

This is *A. punctulatus* in the sense in which I have previously understood it.

(3) *A. punctulatus* var. *tesselatus*, Theobald. Proboscis pale on the apical half (above and below). Second joint of palpi markedly longer than the third and fourth together; its basal half black, its apical half entirely white. Oriental Region; also reported by Swellengrebel from Ceram, but this may prove to be the true *punctulatus*.

**Anopheles amictus,** sp. nov.

Differs from *A. annulipes*, Walker, as follows:—Proboscis entirely dark-scaled in both sexes. Antennae of the female shorter and stouter, especially the last few joints, which are neither thinner nor longer than those immediately preceding, the last ten joints all being of about the same length and thickness. Abdomen rather densely clothed with broad, flat scales on all segments except the first; on the dorsal surface the scales are mostly yellowish, with a patch of dark ones in the middle of segments 4–6; on the ventral surface the scales are mostly whitish and less numerous towards the base. White spots on the legs larger, the posterior surface of the front tibiae being almost entirely white. First longitudinal vein with 14–18 small black spots; no long ones.

Queensland: Townsville (*G. F. Hill*), type ♀ and one ♂, presented by the Imperial Bureau of Entomology.

The differences between this and *A. annulipes* seem to be too great to fall within the limits of specific variation, especially as regards the abdomen and antennae; nevertheless, the two are certainly very closely allied, and some specimens show intergradation in some respects. A female from Townsville, 2.ii.1903 (*F. P. Dodd*), agrees with the above definition, and also shows a further difference from *A. annulipes* in that the second, third and fourth joints of the hind tarsi have distinct whitish rings at the base as well as at the tip. A female from Port Darwin agrees with this. A female from Townsville (*F. H. Taylor*), and another from Cardington, Queensland (*F. H. Taylor*), have the scaly abdomen of *A. amictus*, but the antennae are somewhat more slender apically, the proboscis is pale on the apical half, the integument of the mesonotum is ochreous, and the first vein has long black spots. The last two specimens may possibly be *A. mastersi*, Skuse, but regarding both *A. mastersi* and *A. musivus* Skuse states that the *last* abdominal segment bears scales, implying that the others do not. Besides the above-mentioned forms, examples of normal *A. annulipes* have been taken at Townsville.

**Megarhinus (Toxorhynchites) kempi,** sp. nov.

♂. *Head* blue-scaled (? rubbed). Proboscis purple, the thin portion with a greenish tinge. Palpi rather longer than the proboscis, slender; first three joints about equal in length, mainly yellow-scaled, some purple scales, chiefly on upper surface, towards bases of first and second, and at apices of second and third. Fourth joint dark, acuminate, nearly as long as second and third together. Clypeus and basal antennal joints bluish-grey-dusted, shaft of antennae yellow; first flagellar joint with a few dark scales. *Thorax*: Prothoracic lobes clothed with deep blue scales, a few white ones beneath. Pro-epimera and pleurae with silvery-white scales. Mesonotum black, scales mostly metallic green, with some purple ones intermixed (very much rubbed). *Abdomen* without apical lateral scale tufts; dorsal surface mostly metallic purplish blue; first tergite green; remaining tergites each with a narrow basal band of bluish green. Venter mostly yellow; no median purple line; eighth sternite purple. *Legs*: Femora purple above and in front, yellow beneath. Tibiae purple. Tarsi purple, the first joint on all the legs with a rather narrow and ill-defined whitish ring near the base. First hind tarsal joint with rather long and dense bristles beneath, except at the base. Front and middle claws unequal, the larger with a strong median tooth, the small simple; hind claws equal and simple. *Wings* as in *M. leicesteri*. *Hypopygium*: Ninth tergite rather narrow, the bare middle part slightly emarginate apically, fully twice as wide as long; side portions each with 10–12 long hairs. Ninth sternite bare. Side-pieces tapering, nearly three times as long as their basal width; basal lobes triangular, apically with two long and strong bristles. Claspers slightly shorter than the side-pieces, of even width throughout, terminal spine long, strong and pointed; about five fine hairs in a row before the tip. Tenth sternites long and rather slender, their tips not conspicuously enlarged or blackened. Lower bridge of mesosome very narrow and nearly basal; paired processes of mesosome rather slender, distinctly but irregularly serrate above (sternally).

♀. Palpi purple, not longer than the head. Head with mixed colours, mostly blue above and pale round the eyes. Prothoracic lobes purple. Mesonotal scales bright metallic green. White rings on the first tarsal segments more distinct than in the male; the tarsi have also additional white markings as follows:—on the front and middle legs, a small area at the base of the second joint on the underside; on the front legs, the inner and lower side of the fourth joint, except its tip, and the underside of the fifth joint; on the middle legs, practically the whole of the fourth and fifth joints, except the tip of the latter on the upper side. (The last four joints of the hind tarsi are missing.)

India: Talewadi, nr. Castle Rock, N. Kanara district, 3–10.x.1916 (*S. Kemp*), 1 ♂ 1 ♀. *Type* in the Indian Museum.

Closely resembles *M. leicesteri*, Theo., which differs chiefly in having the whole of the last four joints of the middle tarsi of the female white; the ninth tergite of the male is broader, and the paired anterior processes of the mesosome are not serrate.

**Megarhinus (Toxorhynchites) klossi,** sp. nov.

♂. Differs from *M. kempi* as follows:—First joint of palpi a little shorter, third a little longer than second. Scales of prothoracic lobes all purplish blue; those of pro-epimera coppery above; of mesonotum duller, purplish and bronzy, mixed with green; of scutellum coppery. Sides of first abdominal tergite whitish. Ninth tergite broader; tenth sternites more enlarged apically; lobes of mesosome smooth above; clasper with hair-like terminal spine. First hind tarsal joint without dense bristles beneath. From *T. gravelyi* the differences are:—Distinct basal bands are present on the abdominal tergites; ninth tergite is less emarginate; venter is without median purple stripe, etc.

Fed. Malay States: Kedah Peak (Gunong Jerai), 3,200 ft., xi–xii.1915 (*C. Boden Kloss*), 1 ♂. *Type* in the British Museum.

**Megarhinus (Toxorhynchites) gravelyi,** sp. nov.

♂. *Head* mostly dark-scaled (colour varying with the light), a pale rim round the eyes. Proboscis purple, more greenish on the thin apical portion. Palpi slender, slightly longer than proboscis; first joint distinctly shorter than the second or third, which are about equal in length, and together about as long as the fourth; the palpal scales are purple, on the underside of the first three joints, except towards the tip of the third and the base and extreme tip of the second, mostly golden. Second antennal joint with some golden scales. *Thorax*: Prothoracic lobes and pro-epimera coppery-scaled above, silvery white below; pleurae silvery-white-scaled; mesonotal scales bright metallic green; scutellar scales coppery, a few whitish ones at the sides. *Abdomen*: First tergite bluish green in the middle, shining creamy white at the sides; remaining tergites deep blue, with basal lateral creamy spots. A few yellow hairs at the sides of tergites 6 and 7, not forming definite tufts. Venter golden, with a narrow median purple line; eighth sternite purple. *Legs* purple-scaled; femora golden beneath and towards the base; first joint of all tarsi with a narrow indistinct pale ring near the base (joints 3–5 of hind tarsi denuded). First hind tarsal joint without dense bristles beneath. *Wings* with the cross-veins nearly in a line, the m-cu cross-vein somewhat oblique outwardly. *Hypopygium*: Ninth tergite strongly emarginate apically, narrow in the middle, with well-developed hairy lobes, each bearing 10–15 hairs. Ninth sternite bare. Side-pieces tapering, hardly more than twice as long as their width at the base. Basal lobes with three strong bristles, one weaker than the others. Tenth sternites stout, blackened and somewhat enlarged apically. Claspers as long as the side-pieces, slightly tapering at the tip, terminal spine long, strong, pointed. Mesosome with the lower bridge very narrow, basal; lobes rather slender, smooth above.

India: Pashok, Darjiling district, 2,000 ft., E. Himalayas, 26.v.–14.vi.1916 (*F. H. Gravely*), 1 ♂.

*Type* in the Indian Museum.

Resembles *T. metallicus*, Lin., differing in the darker upper side of the palpi, coppery rather than purple scales on upper part of prothoracic lobes and pro-epimera; presence of pale rings on first tarsal joints, and more emarginate ninth tergite.

**Opifex fuscus,** Hutton.

This species was originally described from New Zealand by Hutton (Trans. N.Z. Inst., xxxiv, p. 188, 1902) as a Tipulid, and its true position has not till now been recognised. Recently a number of specimens have been presented to the British Museum by Mr. G. V. Hudson, taken on the ocean beach at Wellington, N.Z.

The insect is a Culicine mosquito, presenting many remarkable features; though its peculiarities seem to be mainly connected with sex, it certainly cannot be placed in any previously known genus of Culicidae, and it is difficult to place it precisely in relation to the other genera of the Culicini. It seems to be nearer to *Aëdes* than to *Culex*. The following are the most striking features:—

*Male.*—Antennae rather stout, not plumose, the terminal joints not lengthened; the first joint conspicuously hairy; the third, fourth and fifth joints a little shorter than those which follow, and each bearing a strong spine at the base on the upper side, the spine on the fifth joint very long. Proboscis and palpi strongly curved; the palpi two-thirds as long as the proboscis, the last joint forming a club. The head has no upright scales, these being replaced by hairs. Eyes well separated. Abdomen in several specimens curled under the thorax. Hypopygium with the side-pieces simple, broad at the base, pointed at the tips, a membranous strip along the inside from base to tip; clasper subapical, short, with strong terminal claw and sub-basal projection; anal segment well developed, tenth tergites hairy, tenth sternites each ending in a single strong sharp point; aedeagus of simple structure, resembling that

of *Ochlerotatus*. Femora and tibiae stout, especially on the front legs, where the tibiae are swollen and very short, not more than two-thirds as long as the femora. Fifth joint of front tarsi very small, not longer than broad, but the claws enormous, longer than the last three tarsal joints together, equal, simple, divaricate. Claws of middle and hind legs moderately large, equal and simple. Wings as in *Aëdes*.

*Female*.—Antennae and front legs not specially modified; claws all simple. Palpi about a quarter as long as the proboscis. Abdomen rather blunt; cerci rather short and broad; eighth sternite very large.

The peculiar antennae and front legs of the male must have some special biological significance, and it is to be hoped that New Zealand collectors will be able shortly to work out the life-history of the insect.*

**Leicesteria annulipalpis** (Theobald).

In my paper on the genus *Leicesteria* (Bull. Ent. Res., iv, pp. 255–263, 1914) I expressed doubt as to the correct location of *L. annulipalpis*. Recently, however, a female has been received from Dr. N. H. Swellengrebel, taken at Mandailing, Sumatra, which shows that the species really is a true *Leicesteria*. This Sumatran specimen agrees with Theobald's description, except that the claws show a slight swelling towards the middle, which evidently represents a tooth.

**Aëdes (Stegomyia) dendrophila,** sp. nov.

Closely related to *S. fraseri*, Edw., differing almost solely as follows:—Middle femora without a white spot in the middle in front. Hypopygium of male with the side-pieces shorter, less than twice as long as their breadth at the base; basal lobes larger, more densely hairy; *claspettes entirely unrepresented*; claspers shorter, straighter, and less attenuated apically.

Gold Coast: Nsawam, 16.iii.1920 and 14.iv.1920, 2 ♂, 3 ♀, reared from larvae in hole in cotton tree; Oblogo, 17.iv.1920, 3 ♂ (including type), 2 ♀, from tree-hole; Aburi, 6.vi.1920, 5 ♂, 2 ♀, from banana (*Dr. A. Ingram*). Sierra Leone: Freetown, ix.1914, 1 ♀ from tree-hole (*Dr. G. Butler*, presented by *A. Bacot*); previously recorded as *S. fraseri*.

The absence of a white spot on the mid femora would place this species with *S. pseudonigeria* in my key (Bull. Ent. Res., iii, p. 8, 1912). The new species differs from *S. pseudonigeria* as follows:—All tibiae with small whitish spots at the extreme base, not removed from the base, beneath; mid femora all black on posterior surface, except for the apex; second joint of mid tarsi all yellowish white, except beneath towards tip (in *S. pseudonigeria* white at the base only); last two joints of hind tarsi with some dark scales beneath; segments 2–5 of abdomen with narrower whitish basal bands or none.

**Aëdes (Ochlerotatus) bancroftianus,** sp. nov.

*Head* clothed almost entirely with broad, flat scales, a rim of narrow ones round the eyes; the flat scales varying in colour from dark brownish to cream-coloured, generally paler towards the nape; the narrow scales ochreous; ocular bristles pale. Torus ochreous, darker on the inner side. Proboscis dark-scaled and slender throughout, one-third longer than the front femora. Palpi dark-scaled; in the female about one-sixth as long, in the male of exactly the same length as the proboscis; last two joints in the male slightly swollen, with well-developed hair-tufts, the terminal a little shorter than the penultimate. *Thorax* brown, mesonotum clothed in the type with moderately

* Since writing this I learn that Mr. D. Miller, Government Entomologist in New Zealand, has an account of the life history of this insect in course of publication. Larvae and pupae of the species have been received from Mr. G. V. Hudson; they show some resemblances to *Armigeres*.

dark brown narrow scales ; ochreous narrow scales round the front margin, round the ante-scutellar space, and in two lines extending from the scutellum for nearly half the length of the mesonotum ; in other specimens the dark scales are lighter and the pale scales are more numerous, forming an indistinct pale median transverse band. Scutellum with narrow pale ochreous scales. Prothoracic lobes with broadish curved scales ; pleurae with broad flat white ones. *Abdomen* ochreous, with dark brown scales dorsally ; tergites 2–4 with complete basal creamy bands, broadening somewhat laterally, 5 and 6 with lateral basal creamy spots. Venter pale-scaled, sternites 4–6 with dark apical bands. In the female the seventh segment is remarkably small, narrow, and partly retracted ; the cerci are long and narrow, nearly three times as long as broad. *Male hypopygium* : Side-pieces nearly cylindrical, almost four times as long as their width at the base, without lobes, but with an aggregation of hairs into a small dense patch at the base of the lower flap. Claspettes entirely unrepresented. Claspers long, the outer third rather suddenly narrowed and curved inwards ; terminal spine long, slender, almost straight. Lobes of ninth tergite small, with a few short bristles. Mesosome rather short and broad, simple. Anal segment normal. *Legs* entirely dark-scaled, except for the undersides of the front and middle femora, and the greater part of the hind femora, except the tip and a line along the upper side of the outer half. Claw-formula :— ♂ 2 : 1. 1 : 1. 0 : 0 ; ♀ 1 : 1. 1 : 1. 0·0. *Wings* entirely brown-scaled ; scales of the lateral series long, linear, those of the median series also rather long. Cell $R_2$ as long as its stem in the male, longer in the female, its base slightly proximal to that of cell $M_1$. *Halteres* ochreous, knob somewhat darker. Wing-length 3·5–4 mm.

Queensland : Eidsvold (*Dr. T. L. Bancroft*). Type female, 12 other females, and 3 males presented to the British Museum by the Imperial Bureau of Entomology ; received through Mr. G. F. Hill.

The only near ally of this species is *O. multiplex*, Theo., which differs in thoracic ornamentation, in the larger seventh segment of the female abdomen, and in the straighter and nearly cylindrical male claspers.

**Aëdes (Ochlerotatus) ashworthi,** sp. nov.

*Head* clothed at the sides with broad flat whitish scales ; in the middle of vertex with loosely applied narrower flat straight scales ; on the nape with quite narrow curved scales ; bristles black. Proboscis dark-scaled, slender, nearly one-half longer than the front femora. Palpi dark-scaled ; in the female nearly one-fourth as long as the proboscis, the second joint swollen and longer than the first ; in the male about four-fifths as long as the proboscis, long joint almost divided in the middle, equal in length to the last two joints together, tip of long joint and whole of penultimate joint with long dark hair, terminal joint very broad, slightly shorter than penultimate, nearly bare. *Thorax* : Integument of mesonotum dark brown, with large pale humeral patches, and traces of three blackish longitudinal lines ; mesonotal scales all narrow, mostly ochreous, with some black ones intermixed. Pleurae with some flat, dull whitish scales. *Abdomen* brown, a broad band of dull grey scales at the base of each segment. Seventh segment of female large ; eighth sternite also rather large and prominent ; cerci very small, not longer than broad. *Male hypopygium* : Lobes of ninth tergite clothed with short hairs. Side-pieces about 3·5 times as long as broad, the lower flap without lobes, but bearing on its edge a row of peculiar bristles which are flattened towards the tips, almost club-shaped, these bristles extending for more than two-thirds of the distance from the base of the side-piece. Claspette represented by a small basal lobe of the upper flap of the side-piece, this lobe truncating apically and bearing about a dozen rather long twisted scales or flattened bristles. Claspers long, nearly cylindrical, gradually narrowed and somewhat curved on the apical half, with a moderately long terminal spine. Mesosome rather short and broad, simple. *Legs* dark, except for the whitish undersides of the femora and the narrowly ochreous tips

of the femora and tibiae. Claw formula: ♂ 2 : 1. 2 : 1. 1 : 1 ; ♀ 1 : 1. 1 : 1. 1 : 1. *Wings* entirely brown-scaled ; scales of the lateral series long, linear ; those of the median series also rather long. Cell $R_2$ over twice as long as its stem in the female, its base slightly proximal to that of cell $M_1$. Wing-length 4–4·5 mm.

*Larva*: Head rather broad for this group ; clypeal hairs all simple. Antennae moderately long, slightly curved, almost cylindrical and nearly bare ; a single hair just beyond the middle. Comb of eighth abdominal segment consisting of a triangular patch of 50 or more pointed scales. Siphon about three times as long as its greatest breadth, slightly contracted at base and tip, not very strongly chitinised. Pecten short, consisting of about 12 (fewer in the younger larvae) sharp-pointed, simple teeth, placed so close together that their bases touch ; the first of these teeth is situated at about one-fifth of the length of the siphon, but in some specimens the actual pecten is preceded by one or two small, widely-spaced, simple bristles. Hair-tuft of about eight hairs, situated a little beyond middle of siphon. Tracheal tubes very large, strongly chitinised, occupying almost the whole of the middle part of the siphon, but strongly and abruptly contracted before the base of the latter. Anal segment with a lightly chitinised saddle ; gills very small and globular. Brush well-developed, with 10–12 elements.

West Australia: Yallingup, ix.1914 (*Dr. J. H. Ashworth*). Type and one other male, one female, and a dozen larvae presented to the British Museum by the Imperial Bureau of Entomology in 1915.

This species is nearly allied to *O. crucians*, Walker (*tasmaniensis*, Strickland), and *O.* (*Caenocephalus*) *concolor*, Taylor, differing from both chiefly in the details of the hypopygium. *O. crucians* has the clasper very much swollen in the middle, its terminal spine shorter and stouter, and the flattened bristles on the margin of the side-pieces much less numerous ; the terminal joint of the male palpi is much more slender. Probably the specimens of *O. concolor* from Tasmania recorded by Taylor are really *O. crucians* ; the true *O. concolor* from New South Wales (which was wrongly described as having simple female claws) resembles *O. crucians* in its hypopygium, but the claspers are less swollen, the scales on the claspette lobes are less numerous, and the last joint of the male palpi is swollen, as in *O. ashworthi*. Doubtless the three forms are geographical representatives of the same type.

**Aëdes (?Skusea) funerea,** Theobald.

A male and female, apparently of this species, have been received from Dr. Swellengrebel, from Amboina. No Australian male is available for comparison, and the identification is therefore not absolutely certain, though probably correct. The male hypopygium of the Amboina specimen does not show the least resemblance to *S. pembaensis*, but, on the other hand, resembles that of *Aëdes panayensis*, Ludlow ; from this it differs in the absence of a long process at the base of the side-piece, and in the presence of a short spine instead of a thick projection at the tip of the side-piece. Probably the species would be better placed in the subgenus *Aëdes* than in *Skusea*, but much more knowledge of the biology of these forms is necessary before their classification can be regarded as satisfactory.

**Aëdes (? Skusea) funerea** var. **ornata,** Theobald.

*Lepidotomyia lineata*, Taylor, Trans. Ent. Soc., 1914, p. 191 (1914).

A male and female have been received from Dr. Swellengrebel from Ceram. The male hypopygium is identical with that of *S. funerea* from Amboina, and the form is therefore probably correctly regarded as merely a variety of *S. funerea*, in spite of the striking difference in thoracic ornamentation. Two female paratypes of *L. lineata*, sent by Mr. G. F. Hill, agree with the female from Ceram.

**Aëdes (Skusea) punctipes,** sp. nov.

♀. *Head* entirely clothed with rather close-lying, flat blunt-ended scales; on the upper surface three black patches alternate with four white ones, black scales occurring again low down at the sides. Eyes separated by a rather narrow white-scaled line. Proboscis dark-scaled, not swollen at the tip, equal in length to the front femora. Palpi dark-scaled, rather more than a quarter as long as the proboscis. Antennae missing. *Thorax*: Prothoracic lobes and pro-epimera with rather broad white scales; mesonotum with narrow curved white scales round the front margin, narrow light bronzy-brown scales rather densely covering the rest of the surface; these scales are somewhat broader and denser on the posterior portion of the mesonotum, while on the space in front of the scutellum, which is normally bare, as well as on the scutellum itself, are broad flat blackish-brown scales; a small patch of similar scales above the root of each wing. Postnotum bare. Pleurae with patches of flat white scales. Mesonotal bristles mostly denuded, probably rather long and dense. *Abdomen* brown-scaled above, except the first tergite, which has creamy scales; tergites 2–7 have lateral white spots, which are not quite basal in position and extend a short way on to the dorsal surface. Venter mostly pale, apical sternites dark-scaled apically. The eighth segment and cerci are not visible externally; sixth and seventh sternites prominent in side view. *Legs* mostly brown-scaled; femora lighter beneath, and with a distinct whitish preapical ring; extreme tips of femora and tibiae also whitish. Front tibiae with three, middle and hind tibiae with four small, but distinct, whitish spots on the anterior surface. First joint of all tarsi with a narrow white ring at the base; junction of first and second joints with a small white dorsal spot; first mid-tarsal joint also with a median dorsal white spot, which on the hind legs becomes a complete narrow white ring; second hind tarsal joint narrowly white at the tip. Tibial bristles short, pale. Mid and hind tibiae equal in length. First tarsal joint on front legs about half as long as the tibia, and distinctly shorter than the remaining joints together; on hind legs about two-thirds as long as the tibia. Claws simple. *Wings* brown-scaled, except for the base of the fifth longitudinal vein, which is white. Scales all rather long and broad, mostly obliquely truncate at the tips; only a few longer and narrower ones towards the tips of the veins and along the lower margin of the upper branch of the fifth vein. Wing-fringe very long. Upper fork-cell fully twice as long as its stem, and with its base nearer the base of the wing than that of the lower.

Upper Burma: Maymyo, xi–xii.1913 (*Major Bennett*), 1 ♀.

*Type* in the Indian Museum.

A very distinct species, easily recognised by the leg markings and thoracic scaling. The structure of the abdomen and claws shows that it is quite closely related to *Stegomyia periskeleta*, Giles (=*Ochlerotatus annulifemur*, Edw.), and *S. microptera*, Giles. Both these species have male palpi of the *Ochlerotatus* rather than of the *Stegomyia* type, and, on the other hand, show some relation to *Armigeres* in the structure of the mesosome of the aedeagus. The type species of *Skusea* (*S. pembaensis*, Theo.), though with very dissimilar hypopygium, agrees with these Oriental species in general appearance and in the structure of the male palpi and female abdomen and claws, and all four are probably best relegated to the same genus or subgenus of the *Aëdes* group. The new species, like its ally *S. microptera*, may be expected to be a tree-breeder. It is in such habitats that the species showing the most striking variations from the normal type of Aëdine structure are found, sometimes, as in the present instance, indicating connections with other groups.

**Culex crinicauda,** nom. nov.

*Culex parvus*, Taylor, Bull. N. Terr. Austral.; 1a, p. 27 (1912); nec *Culex parvus*, Macquart.

Although my suggestion that this might be synonymous with *C. vishuni*, Theo., was adopted by Taylor, such is, nevertheless, not the case. The hypopygium of a

male determined by Taylor and sent by Mr. G. F. Hill is very different from that of *C. vishnui*, and shows some peculiar characters. The clasper is unusually broad, almost straight, and has round its base a rather dense tuft of hairs. The lobe of the side-piece bears the usual leaf and filaments, but the filament adjacent to the leaf is remarkably long, flattened, and backwardly (caudally) directed.

**Culex taylori,** nom. nov.

*Leucomyia annulirostris*, Taylor, Trans. Ent. Soc. 1913, p. 696 (1914); nec *Culex annulirostris*, Skuse.

A male paratype has been received from Mr. G. F. Hill. The species appears to be a distinct one, allied, as Taylor stated, to *C. sinensis*, Theo., but differing in having the pale bands of the abdomen confined to the bases of most of the segments, and without pale spotting on the tibiae. From *C. sitiens* it differs in the much broader pale apex to the last palpal joint.

**Culex basicinctus,** nom. nov.*

*Leucomyia annulata*, Taylor, Trans. Ent. Soc. 1913, p. 695 (1914); nec *Culex annulatus*, Schrank.

Two males and three females have been received from Mr. G. F. Hill, collected by him at Townsville. They were sent as *Leucomyia annulirostris*, but agree with Taylor's description of *L. annulata*, and are almost certainly that species. *C. basicinctus* seems nearly allied to *C. whitmorei*, Giles, and, like that species, has the pale rings of the tarsi confined to the bases of the joints, and the pale bands of the abdomen angularly produced in the middle; it differs obviously in many points, *e.g.*, its larger size, duller thoracic colouring, and broader white tip to the last joint of the male palpi. A peculiar character, not mentioned by Taylor, is that the male palpi have two black bristles at the extreme tip, which are conspicuous against the adjacent white hairs.

**Culex ventrilloni,** Edw.

*Culex ventrilloni*, Edwards, Bull. Ent. Res. xi, p. 135 (Sept. 1920).

*Culex albigenu*, Enderlein, Wien. Ent. Zeitschr. xxxviii, p. 50 (Nov. 1920).

A male of *C. albigenu* lent me by Dr. Enderlein enables me to state the above synonymy. Somewhat unexpectedly, the species proves to be a true *Culex*, in Dyar's most restricted sense; the hypopygium has almost the same structure as in the African *C. simpsoni*, Theo., and *C. andersoni*, Edw.

**Culex quasigelidus,** Theo.

*Culex auritaenia*, Enderlein, Wien. Ent. Zeitschr. xxxviii, p. 49 (Nov. 1920).

The above synonymy, evident from the description, is confirmed by the examination of specimens sent by Dr. Enderlein.

**Culex (Lophoceratomyia) jenseni** (Meij.).

*Cyathomyia jenseni*, de Meijere, Ann. Jard. Bot. Buitenzorg, (2) iii, p. 922 (1910).

*Lophoceratomyia curtipalpis*, Edwards, Bull. Ent. Res. v, p. 127 (1914).

The above synonymy is proved by comparison of the type of *L. curtipalpis* with a paratype of *C. jenseni*, presented to the British Museum by Professor de Meijere. The species is wrongly placed in my table of the species of this subgenus (Bull. Ent. Res. vii, p. 227, 1917); it should come under heading 9, differing from the other species there included in the shorter male palpi.

* [There does not appear to be any reasonable ground for proposing this new name. Schrank's species was transferred to *Theobaldia* long before *Leucomyia annulata* was described, and there can be no possibility of confusion between them.—Ed.]

My previous use of the name *Cyathomyia* in the sense of *Protomelanoconion*, Theobald, proves therefore to be erroneous; if the group is retained as a distinct subgenus of *Culex*, Theobald's name will have to be revived, *Cyathomyia* falling as a synonym of *Lophoceratomyia*. However, *C. brevipalpis*, Giles, and *P. fuscum*, Theo., have a hypopygium constructed much as in *Neoculex*, Dyar, and should probably be referred to that subgenus.

**Rachisoura filipes** (Walker).

*Culex filipes*, Walker, Proc. Linn. Soc. v, p. 229 (1861).

*Rachisoura sylvestris*, Theobald, Mon. Cul. v, p. 208 (1910).

*Stegomyia hilli*, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 456 (1914).

*Mimeteomyia hilli*, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 566 (1916).

The above synonymy appears to be proved by a comparison of Walker's and Theobald's types with a specimen of *S. hilli* from Stapleton, Northern Territory, sent by Mr. G. F. Hill. The genera *Rachisoura* and *Mimeteomyia* are probably not distinguishable; they differ from *Rachionotomyia* in the shorter and stouter proboscis, which is little, if any, longer than the front femora.

**Rachionotomyia aenea,** sp. nov. ♀.

*Head* dark-scaled, with a moderately broad pale band in front, which is blue or whitish according to the direction of the light. Palpi and proboscis purplish-scaled, the palpi exceeding the clypeus by about twice the length of the latter. Antennal torus orange. *Thorax* with the integument orange-brown, darker brown on the mesonotum. Prothoracic lobes with black bristles and narrow, almost hair-like, dark brown scales. Mesonotum with narrow dark brown scales, except on, and just in front of, the scutellum and between the scutellum and the wing-bases, where the scales are broad, flat and bronzy-green in colour. Pleurae with a large silver-scaled dark brown patch. *Abdomen* purplish-black above, golden beneath, the tergites with lateral subapical bluish-silvery patches. *Legs* purplish-scaled; middle femora in front with a silvery streak on the basal half and a silvery subapical spot; front and hind femora unmarked. *Wings* with dark brown scales; those on the fork-cells short and rather broad. Upper fork-cell slightly longer than its stalk, its base distinctly distal to that of the lower. Cross-veins separated by more than the length of the posterior. Wing-length 3 mm.

Malay States: Edges of stream, Ampang jungle, Kuala Lumpur, 21.v.1904 (*Dr. G. F. Leicester*), 1 ♀.

Allied most nearly to *R. similis*, Leicester, differing in the unspotted front and hind femora, and in some other points.

**Rachionotomyia purpurata,** sp. nov. ♀.

Nearly allied to *R. bimaculipes* (Theobald), differing as follows:—Integument of mesonotum orange, almost dull (instead of shining blackish), clothed with narrow greenish scales mixed with some black ones; pro-epimera with small flat black scales (bare, perhaps rubbed, in *R. bimaculipes*); dark scales of abdomen with strong purple reflections (instead of dull black).

Fiji Is.: Suva, 10.iv.1911, 3 ♀ reared from larvae (*Dr. P. H. Bahr*, pres. by *Lt.-Col. A. Alcock*).

**Rachionotomyia quasiornata** (Taylor).

*Stegomyia quasiornata*, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 177 (1915).

This is very similar to *R. bimaculipes* and *R. purpurata*, but differs from both in having narrow instead of broad and flat scales on the prothoracic lobes. A female has recently been received through the Imperial Bureau of Entomology, named by Mr. G. F. Hill after comparison with Taylor's type; it shows the long proboscis characteristic of the genus. In all these three Australasian species the palpi are shorter than in the Oriental forms, exceeding the clypeus by hardly more than the length of the latter.

# BIOLOGICAL STUDIES OF APHIS RUMICIS, LINN.*

By J. Davidson, D.Sc.

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This is the first of a series of papers based on results of breeding experiments and on observations in the field. It is hoped that a full investigation of the biology of this species will be of value in elucidating the many difficult biological problems of the Aphididae.

The preliminary paper published by the author (1914) was to have been followed by further investigations, but owing to the outbreak of the European War there has been an unavoidable delay. However, experiments are now being continued, and the results of the researches will be published in parts from time to time.

As there is no complete description of *Aphis rumicis* in the literature, it is thought very desirable that a detailed illustrated description of all forms of this species should be given.

The following abbreviations are used in the text:—a.v. ♀ = apterous viviparous female; w.v. ♀ = winged viviparous female; 1st v. gen. = 1st, 2nd, etc., viviparous generation.

## I. Description of Aphis rumicis, Linn.

1. Fundatrix (fig. 1). Average size, 1·8 mm. by 1·4 mm.†

*Body* oval to elongate, broadly rounded posteriorly, shorter and relatively stouter than the succeeding a.v. ♀♀; colour black to dark green; hairs scattered over the body.

*Head*: A few scattered hairs on dorsal surface. Eyes black; small tubercle-like accessory eyes‡ on posterior margin. Antennae§ about two-thirds length of body; black to dark brown, paler about the middle; five segments; seg. 3 the longest; 1 slightly broader than long; 2 slightly longer than broad, subequal in length; 4 shorter than 5; 5 almost as long as 3; a single subapical sensorium on seg. 4 and a compound sensorium on seg. 5; a few short hairs on each segment. Rostrum normal, with a few hairs on each segment.

*Thorax*: A pair of prominent lateral tubercles on prothorax. Legs black, with tibiae and proximal portions of femora paler; segments bearing many short hairs, especially the tibiae.

*Abdomen* with two prominent lateral tubercles on each side. Cornicles black to dark brown, imbricated, tubular, tapering very slightly distally, shorter than in succeeding a.v. ♀♀; about one and one-third times the length of cauda as seen from the dorsum. Cauda short, bluntly rounded, black on distal portion; bearing several long curved hairs. Anal plate black, roughly quadrangular as seen from venter, bearing a number of short hairs, anterior margin more or less straight. Genital plate black, somewhat crescentic in shape, with outer margins rounded; bearing a number of stout hairs and short spines.

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* This species is the black aphis found in spring on the spindle tree (*Euonymus europaeus*), and later on beans, poppies, and many other plants. It has many synonyms, owing to its polyphagous habits, but the name given by Linnaeus in 1746 holds priority. The more important synonyms are *Aphis papaveris*, Fabr.; *Aphis euonymi*, Fabr.; and *Aphis fabae*, Scop. For other synonyms see Theobald, 1912.

† The measurements given are total length of body excluding the cauda, and the greatest width of the abdomen. The size is very variable, depending largely on food and temperature conditions.

‡ Accessory eyes (Berlese, "Gli Insetti"); ocular tubercles (Baker, 1920).

§ The "unguis" (Baker, 1920), or "processus terminalis" (Tullgren, 1909), of the terminal segment is here considered as being part of the distal segment.

*First Larval Instar* has 4-segmented antennae, with sensorium on segs. 4 and 5; tubercle-like cornicles; small obtuse cauda and stout legs.

*Second Larval Instar* has 5-segmented antennae.

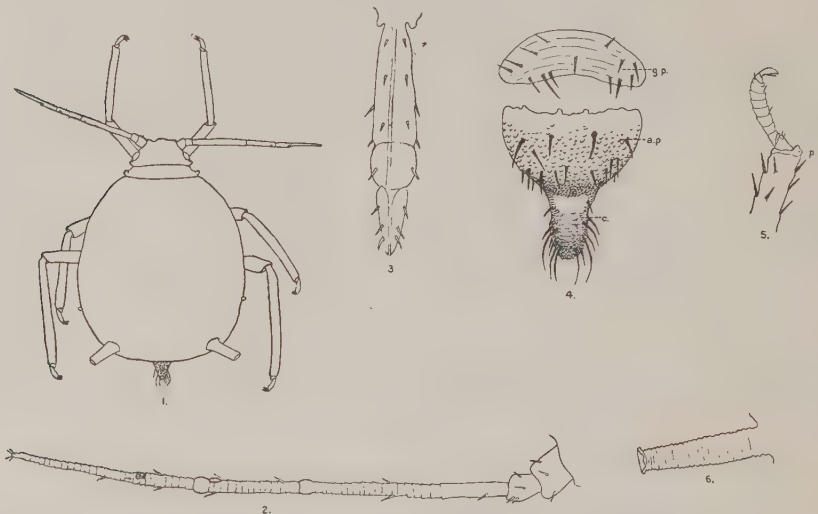


Fig. 1. *Aphis rumicis*, Linn., fundatrix: (1) dorsal view; (2) antenna; (3) rostrum; (4) posterior end of venter, *a.p.*, anal plate, *g.p.*, genital plate, *c*, cauda; (5) tarsus of third leg, *p*, empodium or pad; (6) cornicle.

2. Apterous Viviparous Female (fig. 2). Average size 2·5 mm. by 1·6 mm. *Body* elongate oval; colour variable, black to olive-green, often with irregular darker pigmented areas over the abdomen; small hairs scattered over the body.

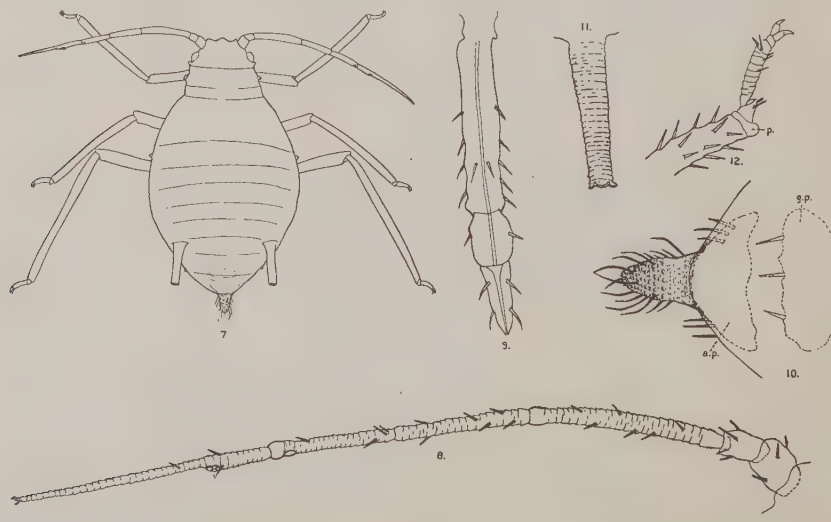


Fig. 2. *Aphis rumicis*, Linn., apterous viviparous ♀: (7) dorsal view; (8) antenna; (9) rostrum; (10) cauda, dorsal view, *a.p.*, anal plate, *g.p.*, genital plate; (11) cornicle; (12) tarsus of third leg, *p*, empodium.

*Head*: Eyes black, with prominent accessory eyes. Antennae six-jointed; seg. 1, apical portion of seg. 5 and proximal portion of seg. 6 black, remainder of a paler colour; seg. 6 (including processus terminalis) the longest, about equal to 4 and 5 together; 3 about three-fourths the length of 6, longer than 4; 4 slightly longer than 5; 1 and 2 subequal in length; a single subapical sensorium on seg. 5; a compound sensorium on seg. 6; a few hairs on all segments. Rostrum normal, with a few hairs on the segments.

*Thorax* with a prominent prothoracic tubercle on each side. Legs black; tibiae and proximal portion of femora paler; segments bearing stout hairs, especially the tibiae.

*Abdomen* with two lateral tubercles on each side and sometimes one or two small indefinite tubercles. Cornicles black, tubular, imbricated, slightly tapering distally, varying in length, but usually about one and one-third to one and one-half times the length of the cauda as viewed from dorsum. Cauda with distal half slightly spoon-shaped, black, clothed with short stout bristles and several long curved hairs. Anal and genital plates as in fundatrix.

3. Winged Viviparous Female (fig. 3). Average size, 2·4 mm. by 1·3 mm.

*Body*: Head and thorax black to brownish black; the abdomen varying from dirty brownish black to olive-green, usually with irregular darker pigmented areas on the abdomen. Small hairs scattered over the body.

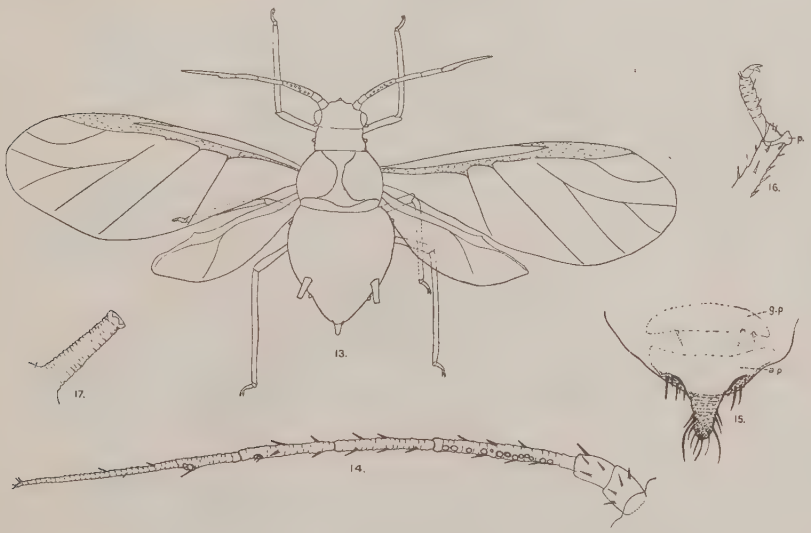


Fig. 3. *Aphis rumicis*, winged viviparous ♀: (13) dorsal view; (14) antenna; (15) cauda, dorsal view, *a.p.*, anal plate, *g.p.*, genital plate; (16) tarsus of third leg, *p*, empodium or pad; (17) cornicle.

*Head* black. Eyes black, with prominent accessory eyes. Antennae dirty brown to black, varying in length, about two-third length of body; seg. 3 slightly longer than 4; seg. 4 slightly longer than 5; 1 and 2 subequal; subapical sensorium on seg. 5, and a compound sensorium on seg. 6; a varying number of about 12–18 subcircular sensoria distributed over seg. 3 and none or 1–4 over seg. 4; segments 3 to 6 imbricated. Rostrum dark towards distal end; normal.

*Thorax* with two prominent lateral tubercles on prothorax. Wings normal. Legs somewhat longer than in a.v. ♀, otherwise similar.

*Abdomen* varying in colour from dark velvet-black to olive-green, usually with five irregular pigmented areas along the lateral dorsal area and irregular transverse areas segmentally arranged; lateral tubercles prominent. Cornicles black, varying in length, usually about one and one-half times length of cauda as viewed from dorsum, imbricate, tubular, slightly tapering distally. Cauda not so large as in a.v. ♀, otherwise similar. Anal and genital plates as in a.v. ♀.

4. Sexuparae.

(*a*). Male-producing sexuparae, apterous, resembling apterous viviparous female.

(*b*). Female-producing sexuparae, winged, resembling winged viviparous female, but somewhat larger in size.

5. Male (fig. 4). Average size, 1·4 mm. by 0·7 mm.

*Body* smaller than in w.v. ♀, narrower and more tapering distally; seen from dorsum it appears to be shining black, but the abdomen is often very dark green; small hairs scattered over the body.

Fig. 4. *Aphis rumicis*, ♂: (18) dorsal view; (19) antenna; (20) rostrum; (21) cornicle; (22) tarsus of third leg; (23) posterior end of venter, showing genital armature, *a.p.*, anal plate, *c*, cauda, *cl.*, claspers, *p.s.*, penis sheath; (24) cauda, dorsal view.

*Head* black. Eyes large, black; accessory eyes prominent. Antennae about two-third to three-quarters length of body, black, but sometimes paler; segments 1 and 2 subequal; 3 shorter than 6; 4 slightly shorter than 3; numerous subcircular sensoria on segments 3, 4 and 5, and a compound sensorium on 6; a few hairs on all segments. Rostrum normal.

*Thorax* black and shining; prothoracic tubercles prominent. Legs slender, black, with greater part of tibiae and femora paler; hairs on all segments, especially tibiae.

*Abdomen* varying, almost black to dark green, black along lateral margins, irregular patches of darker pigmented areas more or less segmentally arranged; two lateral

tubercles present on each side. Cornicles dark to black, short, small, tubular, imbricated, a little longer than the cauda viewed from the dorsum. Cauda smaller than in w.v. ♀; covered with short spines and several long hairs; distal portion black. Anal plate black. Genital plate black, bearing two dark claspers (gonapophyses) clothed with spines and stout hairs. Penis sheath paler.

6. Oviparous Female (fig. 5). Average size, 1–6 mm. by 0·9 mm.

*Body* small and narrow compared with the a.v. ♀, tapering posteriorly; dirty brownish black to dark green in colour, often of a dark green velvety appearance; short hairs distributed over the body.

*Head* black to dark green. Eyes small, black; accessory eyes small. Antennae about two-thirds length of body; pale dirty grey, segments 1 and 2 and distal portion of 4 and 5 darker; seg. 6 about equal in length to 3, 4 and 5 together; 3 longer than 4 or 5; 4 slightly shorter than 5; a compound sensorium on seg. 6 and a subapical sensorium on 5; a few hairs over each segment. Rostrum normal, dark on distal portion, with fewer hairs on the segments.

*Thorax* with lateral tubercles on prothorax prominent. Legs relatively short and stout; of a dirty greyish colour, with coxae, trochanters and tarsi darker; hairs on all segments, especially on tibiae; tibiae of third pair of legs much swollen, and possessing numerous irregular roundish light-coloured areas (? sensoria) over the whole length.

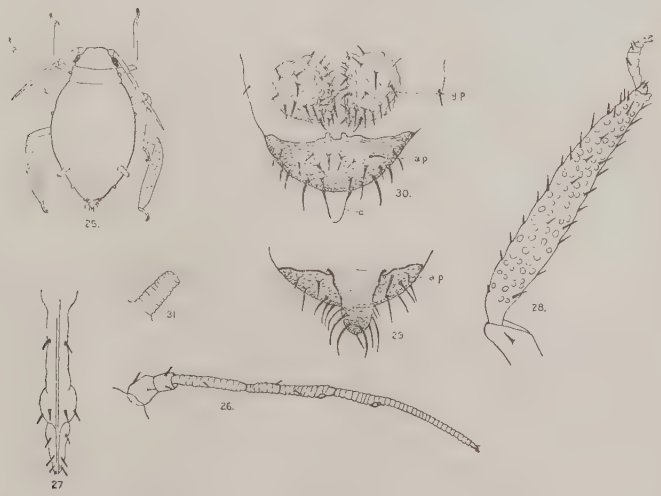


Fig. 5. *Aphis rumicis*, oviparous ♀: (25) dorsal view; (26) antenna; (27) rostrum; (28) tibia of third leg; (29) cauda, dorsal view; (30) posterior end of venter, *a.p.*, anal plate, *g.p.*, genital plate, *c*, cauda; (31) cornicle.

*Abdomen* dark green, with occasional lighter-coloured areas; two tubercles on each side. Cornicles quite small, black, imbricated, tubular, a little longer than the cauda as viewed from the dorsum. Cauda small but stout, black on distal portion. Anal plate black. Genital plate bilobed, black, and covered with long hairs.

*Ova*, when first laid, somewhat greenish, but rapidly becoming black and shiny on exposure to the air. Average size, 0·5 mm.

## II. Life-History of Aphis rumicis.

The following account of the life-history of this species is based upon extensive breeding experiments and observations in the field. Experiments were carried on during 1913 and the early part of 1914, and continued during 1920.

The Aphids were reared from eggs on *Euonymus*, and transferred to broad beans as the summer host, the winged remigrantes or sexuparae of the later generations being transferred back to *Euonymus*. The plants were grown in pots in a large open glasshouse and kept covered with muslin bags, and observations on the different generations of the Aphids were periodically recorded. It is hardly practicable, for reasons of economy, to publish the observations made on the long series of plants infected, but the records of certain plants will be given in later sections of these biological studies. It is from the data derived from these observations, together with contemporary observations in the field, that the life-cycle has been worked out.

The ova hatch out in spring (March and April) on the winter host, *Euonymus europaeus*,* giving rise to the larvae of the fundatrices. In 8–10 days after birth, in favourable temperature conditions, the fundatrices become adult and begin to produce parthenogenetic viviparous young, which become adult about 10 days after birth. This is the first viviparous generation, and it may consist of a mixed progeny of both alate and apterous viviparous females, or of the latter only. The a.v. ♀ ♀ produce on *Euonymus* the second viviparous generation, which may consist of w.v. ♀ ♀ and a.v. ♀ ♀, the former being generally in the majority. The a.v. ♀ ♀ produce a further generation, consisting either entirely of w.v. ♀ ♀, or of a mixed progeny of w.v. ♀ ♀ and a.v. ♀ ♀, the w.v. ♀ ♀ being in the majority.

There is a tendency for the a.v. ♀ ♀ of these early generations on *Euonymus* to produce w.v. ♀ ♀ in the majority. These w.v. ♀ ♀ are the winged migrants from the winter host to the intermediate or summer hosts, such as beans, poppies, etc. It is owing to this tendency that the a.v. ♀ ♀ on *Euonymus* eventually die out, and as the season advances the tree becomes free from the aphis. Some of the w.v. ♀ ♀ may in some cases remain a short time on *Euonymus* and produce young on it, but owing to the innate desire of the winged forms to migrate (a marked feature of the winged forms when the Aphids are reared in captivity), they soon leave the *Euonymus* and fly to the intermediate hosts.

The generations of individuals from the fundatrices on *Euonymus* are the fundatrigeniae, the a.v. ♀ ♀ being the fundatrigeniae apterae and the w.v. ♀ ♀ the fundatrigeniae alatae. These latter are the winged migrants (migrantes), which fly to the intermediate hosts, being the mothers of the succeeding viviparous generations. The generations of individuals from the migrantes on the intermediate hosts are called the alienicolae, the a.v. ♀ ♀ being the alienicolae apterae, and the w.v. ♀ ♀ the alienicolae alatae.

The intermediate hosts are numerous, but of the cultivated plants beans are specially favourable, and afford the best stimulus to rapid reproduction. The migrantes give rise to the first viviparous generation on the intermediate host, the individuals of which are a.v. ♀ ♀. These produce a further generation, which may consist of a.v. ♀ ♀ or a mixed progeny of w.v. ♀ ♀ and a.v. ♀ ♀. The former may remain a little time on the same plant and produce young, or may fly to other plants, either of the same kind or other hosts, and produce a further generation. My experiments show that the tendency is for w.v. ♀ ♀ to produce a.v. ♀ ♀, and for a.v. ♀ ♀ to produce either a.v. ♀ ♀ or a mixed progeny with a varying percentage of w.v. ♀ ♀. This would

* The spindle-tree is undoubtedly a winter host of *Aphis rumicis*, but considering the local distribution of *Euonymus* in Britain, it is highly probable that there are other winter hosts. Gaumont (1913) found all stages on *E. japonicus*. Mordwilko (1907) found *Aphis euonymi* in spring on *Viburnum opulus* at Bjelovesh. It was also found on *Viburnum opulus* by Kaltenbach (*Aphis euonymi*) and by Passerini (*Aphis papaveris*). It is evident that further research is greatly needed in order to ascertain the common winter hosts of this abundant Aphid.

appear to be an adaptation of the species to its polyphagous habits. Thus when the w.v. ♀ ♀ alight on a new plant a good colony is established on that plant by a.v. ♀ ♀ being produced. On the other hand, the liability to overcrowding as the plant becomes heavily infested is overcome, and the wider distribution of the species to other host-plants is ensured by the production of winged forms in due course.

Towards the end of summer, after a number of agamic generations have been passed through on the intermediate hosts and at a time when suitable intermediate hosts are becoming scarce, there are produced winged viviparous females, which are physiologically specialised, but morphologically resemble the other alienicolae alatae. These are the sexuparae alatae or remigrantes. They fly back to the winter host, on which they produce true oviparous ♀ ♀.

At about the same period winged ♂ ♂ are produced from certain of the alienicolae apterae (sexuparae apterae) on the intermediate hosts and fly to the winter host, where the sexual ♀ ♀ are fertilised. Fertilised eggs are then laid on the winter host, near the buds, or in crevices in the bark of the older branches. These over-winter and hatch out in spring, producing the fundatrices.

The alienicolae apterae on the intermediate hosts gradually die out, owing partly to the tendency to produce w.v. ♀ ♀ or winged sexuparae and ♂ ♂, and partly to unfavourable conditions.* By confining the Aphids to broad bean plants, sexual forms were produced on these plants in due course.†

In my experiments it was found that the alienicolae alatae of any generation could be transferred back to *Euonymus*, on which plant they produced young, and eventually in succeeding generations both sexual ♂ ♂ and sexual ♀ ♀ appeared. Further, it was found that even if the Aphids are bred in successive generations on *Euonymus*, sexual ♂ ♂ and ♀ ♀ will appear in due course. It should be noted, however, that young growth was ensured on the *Euonymus* bushes by cutting them back. Males were first noted on 10th August 1920.

Similarly on beans, on which intermediate host the Aphids were bred continuously from May, several ♂ ♂ appeared in due course, and in some cases oviparous ♀ ♀ were also found. The ♂ ♂ are produced by alienicolae apterae toward the end of summer on the intermediate host-plants, and the oviparous ♀ ♀ by the physiologically specialised alienicolae alatae (sexuparae alatae) on the winter host, at about the same time. The male-producing sexuparae are thus a.v. ♀ ♀. One and the same mother may produce sexual males and sexuparae alatae, but the sexuparae alatae only produce sexual females.

It seems evident that in the adventures of migration the alienicolae alatae of any generation may alight on the winter host (*Euonymus*) and produce young, resulting eventually in colonies consisting of all stages, namely, a.v. ♀ ♀, w.v. ♀ ♀, ♂ ♂ and ♀ ♀. Mordwilko (1907) found all stages on *Euonymus* in Warsaw at end of September 1894. He also found a colony of a.v. ♀ ♀ on *Viburnum opulus* in Warsaw at the end of September.

Similarly, sexuparae alatae alighting on intermediate host-plants may give rise to sexual ♀ ♀, which might thus be found together with colonies of agamic forms and sexual males. This would explain the finding by Theobald (1912) of sexual ♀ ♀ ovipositing on *Rumex*, by Gaumont (1913) on sugar-beet in October 1913, and by Malaquin and Moitié (1914) on haricot beans in October 1913.

* It seems probable that during a mild winter agamic forms may persist throughout on certain plants and carry on agamic reproduction normally in the following year. Davidson (1914) found a colony of apterous agamic females on 30th January 1913 on *Euonymus* at Richmond. The tree was taken into a greenhouse, and agamic reproduction was carried on normally throughout 1913. Several cases of long-continued parthenogenetic reproduction have been observed. The question will be discussed in a later section dealing with the appearance of sexual forms. It may be stated here that I have carried on a parthenogenetic strain throughout winter in a warm greenhouse, winged sexuparae (which produce sexual ♀♀), sexual ♂♂ and parthenogenetic a.v. ♀♀ being produced in each generation from September to May.

† Mordwilko (1907) was not able to obtain females on intermediate hosts.

During the autumn, when the intermediate hosts are mostly unfavourable for the Aphids, the winter hosts, such as *Euonymus*, offer the most favourable food conditions and the greatest chances of survival. From the nature of *Rumex* and other intermediate hosts under winter conditions and the difficulty in ensuring food for the young larvae immediately they hatch out from the eggs in spring, these cases, I think, must only be considered as casual winter hosts. The sexual forms may develop in several generations. In fact, in one series of experiments under favourable conditions of food and temperature, sexual forms appeared in five succeeding generations. Weather conditions and the dying down of the intermediate hosts are very important factors in limiting the length of period over which sexual forms are produced. These questions will be discussed more fully in a later section dealing with the appearance of the sexual forms.

The life-history of *Aphis rumicis* may be illustrated by the following diagram :—

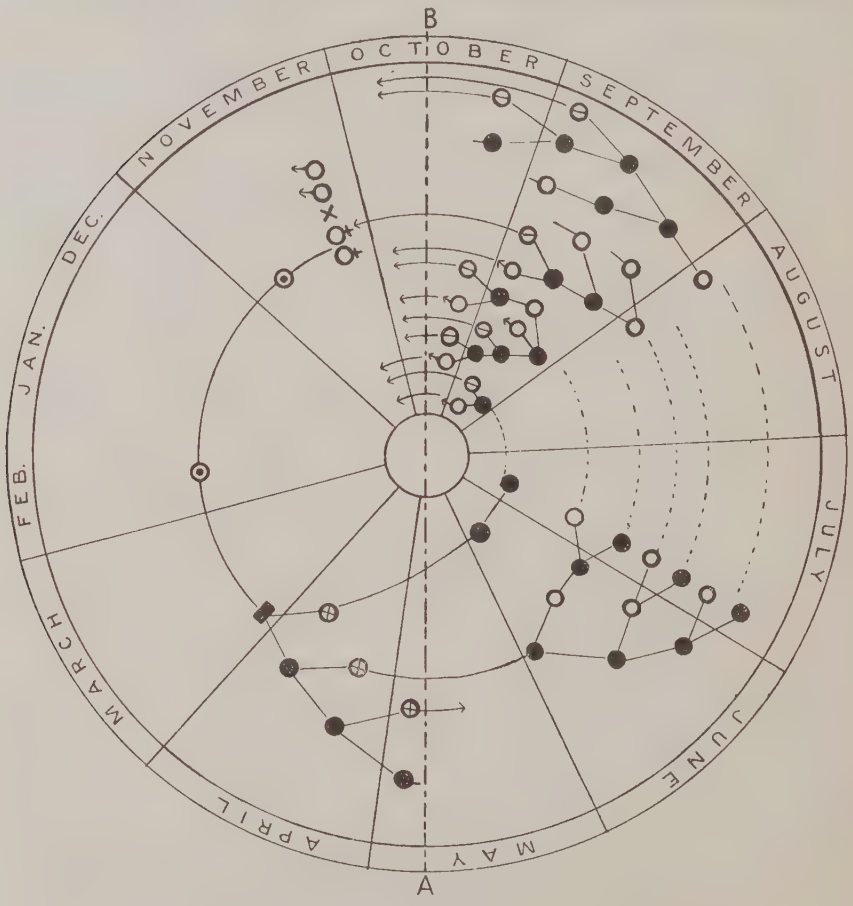


Fig. 6. Diagram illustrating the life-cyle of *Aphis rumicis*. The line AB divides the circle into two halves, the winter host being represented on the left and the summer hosts on the right half ; the sectors indicate the months, and the dotted concentric lines a varying number of generations occurring in July and August.

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# THE NATURE AND FUNCTION OF THE CAUDAL TUFTS OF MALAYAN ANOPHELINE LARVAE.

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It has been found difficult to understand how such a fragile creature as an Anopheline larva could withstand the force of a strong current of water. In the following article it is proposed to explain the phenomenon on anatomical grounds.

The writer's previous experiences in Central Africa, where the seasons are far more definite than in the Federated Malay States, had shown that in the dry period, when there is often an entire absence of other possible breeding-places, the larvae of Anophelines are to be found in among the vegetation fringing the banks of the great rivers; hence, for instance, the notoriety as regards malaria of the whole extent of the Shire valley, in Nyasaland.

It was decided in June 1920 to make a tentative examination for larvae of the Klang River and its affluents in the vicinity of Kuala Lumpur, F.M.S., though there was not at that time any great expectation of being successful in the search. It is true that Dr. Hacker had in 1918 demonstrated the presence there of the larvae of *A. maculatus*, Theo., and *A. aconitus*, Dön.; but apart from the numerous breeding-places afforded elsewhere, swamps, grassy pools, muddy pools, drains, and excavations of various sorts, the heavy rains at frequent intervals during the previous three months had ensured the flow of a volume of water so enormous and a current so swift as to make it appear impossible that an object so fragile as a mosquito larva could maintain itself therein.

A few Anopheline larvae—*A. subpictus*, Grassi, var. *vagus*, Dön. (*A. rossi*, Giles, var. *indefinitus*, Ludl.), *A. barbirostris*, Wulp., *A. hyrcanus*, Pall. (*A. sinensis*, Wied.), *A. aconitus*, Dön., *A. maculatus*, Theo., *A. leucosphyrus*, Dön.—were discovered, and even with the river running strongly, could constantly be found in among the stems of the reeds and long grass at its sides. At no time were they numerous, and careful and diligent search was necessary to obtain them in a rapid current. The significance of their presence would appear to lie, not in their numbers, but rather in their ability to maintain themselves in such a situation, from which in due course the adults can diffuse themselves over the surrounding country, selecting at will, possibly at another season, breeding-places more auspicious to the welfare of their larvae.

The question which then arose was: How do the larvae manage to maintain themselves without being swept away? For not only in the river, but in other running water are the larvae of certain species constantly to be found.

*A. maculatus* larvae, for instance, can invariably be found in a grassy drain beside a railway embankment just outside the town, in which a considerable volume of water is usually flowing. A few *A. karwari* larvae were once found by the writer at Sungei Besi, eight miles south of Kuala Lumpur, apparently quite at ease at the side of a pot-hole through which the water was literally rushing from a higher level. The larvae of *A. aitkeni*, James, almost invariably favour jungle streams.

Some observations made in this connection so long ago as 1911 by Dr. Malcolm Watson, and recorded in his book "The Prevention of Malaria in the Federated Malay States" (p. 105), are of no small interest. Dr. Watson expresses the opinion that the ova of *A. maculatus* (*wilmori*) are laid in the shallowest possible water, usually at the head of a ravine, and the paragraph discussing further the distribution of the larvae is as follows:—

"From these springs the larvae are carried down by the streams, but they cannot be entirely washed out even by the strongest currents or rains. I have found them in

a drain after a two-inch shower. I have watched them at play in a clear pool at the foot of a rock down which water was flowing with considerable force, since the rock sloped to the pool at an angle of forty-five and its face was a foot long. The current of water was still further increased in strength by the rock being funnel-shaped, and all the water coming down the face was gathered into a solid stream as it entered the pool. The larvae were playing not exactly like trout, head to stream, but were floating round in the current, and every now and then one would swim right into the stream, up it for a short distance, and then hang on the side of the apparently bare rock in the full strength of the current." Further on (p. 116) he remarks that " the larvae have the power of attaching themselves to objects."

Anopheline larvae, at all events such as live in moving water, do not, as a rule, go in search of food. They rest at one place, brushing constantly the minute particles carried past into their mouths, consuming such as they wish, and ejecting the rest. It is hardly to be expected that a larva undergoing extremely rapid growth and development, on what would appear to be a precarious method of obtaining food material, could afford to waste any of its energy through having to keep its position by strong and constant muscular effort. Some sort of mechanism involving a minimum expenditure of energy, and not a means similar to the muscular effort that enables a fish to remain at one spot in a stream, was to be looked for. This is found in the dorsal pair of tail fans, the true function of which is now pointed out for the first time, so far as the writer has been able to ascertain.

Patton and Cragg, in their " Text Book of Medical Entomology " (1913, p. 200), describing the ninth segment of an Anopheline larva, state that " the dorsal border is furnished with two pairs of long feathered hairs, which are directed backwards as a tail. The ventral surface bears two rows of feathered hairs arising in the middle line from an elongated and raised area of thick chitin. The two rows are set very close together, so that when examined in side view they appear as one, and hang down at a right angle to the long axis of the body as a sort of fin. Each hair is articulated into a little round pit in the chitinised area."

Giles in his work " Gnats or Mosquitos " (second edition, p. 46), describing the larva of a *Culex*, states that on the last segment, " on either side, but originating in front of the anal tubercles, are a pair of large dense tufts of compound hairs, which are employed in swimming in the same way as a fish's tail, and are so arranged as to form an expansion of similar shape." In his description of an Anopheline larva (p. 60) he states that " the last segment carries four anal tubercles, which, as well as the tail fans, are rather less developed than in *Culex*."

The American authors—Howard, Dyar and Knab—in their " Mosquitoes of North and Central America and the West Indies," do not give any special description of these tufts in Anopheline larvae.

From the foregoing it is evident that no structural differentiation of the two sets of brushes in larvae had been noted. In the larvae of Malayan Anophelines the ventral tufts are as described. But with an objective even of such low power as $\frac{2}{3}$ in. marked differences are to be seen in the dorsal group. For the purposes of description the larva of *A. maculatus* at its last moult may be taken as presenting appearances more or less typical of the majority (fig. 1). In this the dorsal aspect of the ninth segment is furnished at its extremity with two brush-like structures on either side, each just to the outer side of the mid line. The upper and more internal brush consists of a short plume of feathered hairs, which are straight, scanty, and on one side almost double the length of those on the other. Most of the hairs taper gradually and terminate in a sharp point, but one or two of the longer ones may show a terminal hooklet so small as to require a $\frac{1}{6}$ in. objective for its detection. The second structure, just to the lower and outer side of the former, consists of a leash of six stout bristles, five of which are unbranched. They are considerably longer than any in the other brush, there being a slight progressive increase in the length of each, so

that the longest is about a quarter as much again the length of the shortest. All are of about the same calibre, which is practically uniform from end to end, and each of the five is recurved at its extremity, so as to form a rounded hook. The sixth bristle differs from the other five in being considerably shorter and in bearing seven lateral filaments, all of similar calibre but of different lengths, the two longest showing hooks. Not one of the bristles is perfectly straight, each showing a curve first upwards and then gradually in the reverse direction, more sharply towards the extremity. The ventral brushes consist of separate tufts of feathered filaments, arranged fanwise,

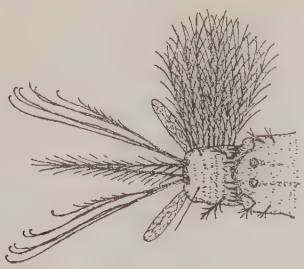

Fig. 1. Terminal segments of larva of *Anopheles maculatus*, Theo.

tapering gradually towards the extremity, which is pointed. They are apparently of less brittle material than the dorsal bristles ; for whereas these often have the hooks broken off, or may be broken short when the larva has been much shaken about, the central filaments seem not to suffer such damage.

The hooked bristles are present throughout larval life. In the newly hatched larva there are two only on each side, and the number increases at each moult. The same structures are to be seen without any modification of form in the larvae of the following Anophelines :—*A. karwari*, *A. hyrcanus* (*sinensis*), *A. kochi*, *A. ludlowi*, Theo., and *A. subpictus* (*rossi*) and its var. *A. vagus* (*indefinitus*). In *A. fuliginosus*, Giles, *A. barbirostris*, *A. umbrosus*, Theo., *A. tessellatus*, Theo., and *A. aconitus*, there are, as a

Fig. 2. Terminal segments of larva of *Anopheles asiaticus*, Theo.

rule, five main hooked bristles only ; in *A. albotaeniatus*, Theo., var. *montanus*, Stant. & Hack., there are, as a rule, five, and the upper of the dorsal tufts shows considerable reduction in size. In the case of *A. aitkeni*, James, and *A. asiaticus*, Theo., there are marked differences ; in *aitkeni* there are six main hooked bristles, one of which shows a branch almost as long as itself and also hooked, so making an additional main limb ; moreover, the upper of the two dorsal tufts shows many more fine hooks at the extremities of the constituent hairs than in other species, doubtless in adaptation to its mode of life, the species breeding in mountain streams ; in *asiaticus* (fig. 2) there are only two, or sometimes three, hooked bristles, which are

attenuated as in *Culex* and often crooked, and show hooks so diminutive as to make the determination of their presence difficult. In this also the upper of the dorsal tufts is reduced to a mere bristle clothed with a few sparse hairs.

It was of interest to learn from Col. Alcock, of the London School of Tropical Medicine, that these structures are present also in two of the British species, and that in the third, breeding in situations comparable with those favoured by *A. asiaticus* in the Federated Malay States, they are, as in that species, absent. The paragraph in his letter, dated 10th August 1920, which he has kindly allowed me to quote, is as follows :—

" On looking at the larvae of the three British species (after reading your letter), I find it to be as you describe in *A. maculipennis* and in *A. bifurcatus*, but not in *A. plumbeus*, that breeds in holes of trees. Now I understand how the larvae of the former two species anchor themselves at right angles to the sides of the aquarium."

Were these structures used for swimming, one would expect to find them at their maximum development in larvae which move more actively than most Anophelines in search of food, but this is not the case. *Stegomyia* probably owe their success as a race of mosquitos, not merely to their being able to breed in almost any situation invariably in stagnant water in which insect enemies are commonly absent, but to the activity they are able to develop in their search, both at the surface and at a depth, for the scanty and miscellaneous food material such places often afford. Placed in a bowl, they may be seen moving constantly, head down, over any surface on which food material may be obtained ; they never remain passive at the side, content to take such food as comes along, as some Anopheline larvae do. In these larvae the various caudal structures are least developed, being represented by a much simpler arrangement of hairs. There are in the last ecdysis three dorsal and three ventral hairs only on each side, all relatively longer than in Anophelines (except in *A. asiaticus*), perfectly straight and tapering gradually so as to end in a fine needle-point.

*Anopheles* larvae may be called on at times to make a sudden and very rapid movement ; this is essential to enable them to escape their enemies, and it is effected by all these larvae, which swim backwards, at all events when on the surface of the water, by sudden contractions of the body, as in the case of *Stegomyia*. But it is essential for such as live in moving water that the movements should be to some extent objective, towards some support, so that they may avoid being swept away. It is suggested that direction is attained by means of rudder-like action of the ventral fans, also much more highly developed than in *Stegomyia*, which, furthermore, enable them on occasion to turn sharply so as to attach themselves to any support by means of the hooks of the dorsal brushes, which have just been described.

The function of the hooks was very readily determined by affording larvae in a glass dish, a small twig as a rough object of support. The larvae of all species except *A. asiaticus*, especially those commonly found in moving water—*A. maculatus* and *A. karwari* for instance—invariably take advantage at once of such a support, resting at a right angle to it. Even with the unaided eye, when the larva is at rest against the support, it can be seen that the caudal tufts are so arranged that the ventral group and the inner dorsal brush remain in direct line with the body, the latter just touching the support, and that the dorsal leash of hooked filaments is directed out on either side at an angle of about 45 degrees to the body. If the supporting object is slightly submerged the brushes are directed down, obliquely or vertically, but still occupy the same relative position. By the aid of a microscope it can be determined that the hooklets are twined round any rough point, so neatly sometimes as almost to tempt one to suspect a real tendril-like action.

If the supporting body is dragged through the water, larvae may be drawn along still clinging to it, and the support may be rather violently moved to and fro, the

attached larvae then swaying backwards and forwards from the point of attachment. Larvae are able readily to attach themselves to moving objects.

In this way, then, the larva is able to avoid being swept away, and it can also employ both sets of hooks together at one point, then resting more or less parallel to the supporting object, its head down current, a measure of value doubtless when it has to sustain itself against a greater pressure of water than it could withstand in any other position. When the larva is floating unsupported against any object, the caudal fans are approximated and directed back, and in this position it was noted occasionally, especially in *A. maculatus*, *A. indefinitus* and *A. aitkeni*, that the hooks from the bristles of opposite sides may be interlocked.

Were any confirmation as to the function of the dorsal tufts needed, it is afforded by the study of these structures in *A. aitkeni* and *A. asiaticus*. In *A. aitkeni*, a regular breeder in mountain streams, the number of hooks available for the support of the larva is at least double, since both dorsal tufts bear them. In *A. asiaticus*, a breeder in bamboos, the structures show a very definite tendency to atrophy, a fact suggesting that the very special sort of habitat selected for the larvae is by no means a very recent choice on the part of the female parent, an inference supported by the size of the primitive larval eye, which is very much smaller than in the larvae of any of the other species of the group, and by the absence of the group of pigment spots arranged in crescentic form, which in other species represent the developing compound eye. It is interesting to note in the case of the bush-breeding Anophelines and in *Stegomyia* (also a breeder by preference in dark places), an approximation to a similar condition.* The presence of any hooks at all in the case of *A. subpictus* var. *vagus*, and others which breed by choice in the still water of muddy pools, is doubtless to be explained by recent modification of breeding habits ; for until the advent of the white man to this country and the subsequent great economic development, there must have been comparatively few such breeding-places available.

Though these hooks must be the chief means of support to larvae, it is certain that the young larvae of *A. maculatus*, *A. karwari* and *A. aconitus* are able to attach themselves to an object for a short period of time by their mouth-parts. It was necessary in the course of some breeding experiments in connection with these species to transfer young larvae from one porcelain bowl to another, and it was repeatedly found that some with their heads applied to the surface of the bowl could resist withdrawal into a glass tube, and that if a current of water was then directed on them, they were not readily dislodged, swaying to and fro at the point of attachment. The porcelain being glazed, it would appear as if they had some power of attachment thereto by suction, no hooklets being present on the mouth-brushes.

The supporting hooks found in the case of the larva would benefit the several species but little, if there were not some sort of counterpart in the case of the pupa. The usual text-book description of the way in which a pupa evades danger is that it does so by diving and keeping itself submerged. Its specific gravity being less than that of water, it remains below either by getting under some object, or by holding fast by clasping it between its thorax and its flexed abdomen. This appears to be true of certain of the Anophelines, but not of all. It was recognised, for instance, by the writer early in the course of a study of *A. vagus* in its muddy pools that the pupa is able to sustain itself with its tail, apparently just simply applied to any portion of

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* In this connection it is noteworthy that, whereas in the fully-grown larvae of *A. hyrcanus* and *A. barbirostris* (open-country breeders) the pigmented elements of both larval and imaginal eyes reach a maximum development, in the case of *A. umbrosus*, the remaining Malayan representative of the *Myzorhynchus* group of Anophelines (a breeder by preference in jungle), they are much reduced in size, especially in the crescentic eye, in which indeed they are so pale that the determination of their presence is difficult.

mud on the bottom. Occasionally a pupa may be seen rising slowly to the surface with material from the bottom dangling from the caudal fins. It has been able so to attach itself by means of a pair of hooklets, one springing from the free margin of each fin, and actually an extension of the thick chitinous bar, which forms a backbone supporting the fin.

If one studies *vagus* pupae in a test-tube, one finds that for the purpose of maintaining themselves below the surface, one of three common methods may be adopted, according to the nature of the supporting material available. First, by preference a pupa will get beneath the supporting object ; secondly, if the object is of convenient size it may clasp it with its anteflexed abdomen ; or thirdly, it may attach itself by the caudal hooks, then rising above the support. Occasionally a pupa of *vagus* has been seen upside down, attached to a rough support by means simply of one respiratory trumpet, showing how slight must be the difference in specific gravity between itself and the water in which it is found. Though the hooks (fig. 3) are present

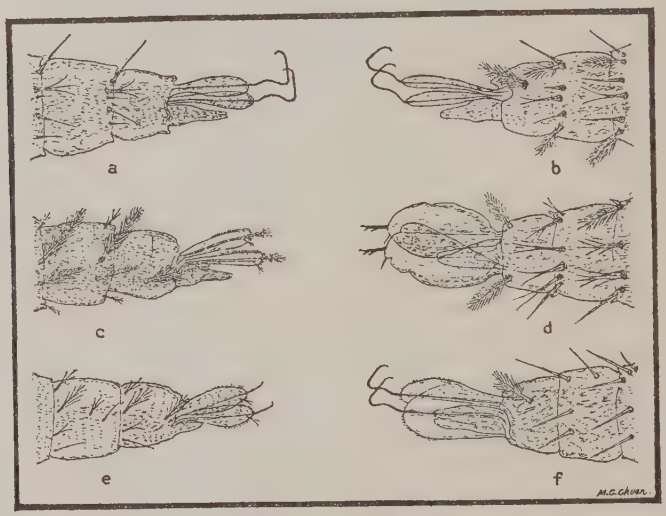


Fig. 3. Terminal segments of pupae of: (*a*) *Anopheles subpictus*, Grassi ; (*b*) *A. subpictus* var. *vagus*, Dön. ; (*c*) *A. asiaticus*, Theo. ; (*d*) *A. hyrcanus*, Pall. ; (*e*) *A. tessellatus*, Theo. ; (*f*) *A. karwari*, James.

in the pupae of *subpictus* (*rossi*), *maculatus*, *karwari*, *aconitus* and *fuliginosus*, they are represented in *sinensis*, *barbirostris*, *umbrosus*, *kochi*, *tessellatus*, *asiaticus*, and, curiously enough, in *aitkeni* also, by a mere filament, and in these latter species, the pupa attaches itself to an object by one of the two ways described first, or, in the absence of any support, remains below by swimming efforts, renewed directly it tends to rise.

The form of the hook varies a little in each species. In all it consists of a stout bristle, which after a short straight course becomes recurved in the direction of the dorsal aspect of the pupa, terminating in a rounded hook. The bristle itself is of brittle material, for often one or both may be broken off short in pupae which have been roughly dealt with.

*Conclusions.*

1. The larvae of certain Anophelines, particularly *A. maculatus*, *A. karwari* and *A. aitkeni*, occur in streams so swift that their presence would have appeared impossible.

2. Some mechanism must be looked for which would enable larvae to maintain their position in the water.

3. A pair of the dorsal tail brushes, terminated by hooklets, provides this mechanism; and there is a counterpart, in the case of certain pupae, in the form of a pair of hooks terminating the paddles.

The writer's acknowledgments are due to Mr. M. C. Chuen, Laboratory Assistant at the Malaria Bureau, Kuala Lumpur, for the care and skill he has exercised in preparing from living specimens, the drawings which illustrate this note.

*Kuala Lumpur, F.M.S.*
*Sept. 1920.*

# FLAX CATERPILLARS IN KENYA COLONY, WITH SPECIAL REFERENCE TO THE LIMITATIONS OF THE ROPING METHOD OF COMBATING THEM.

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Caterpillars on flax in Kenya Colony are farm pests of the first rank. They belong to more than one species, but the one most commonly reared from material from the field is *Phytometra* (*Plusia*) *orichalcea*, F. ; *Heliothis obsoleta*, F., is also met with.

Caterpillars have been reported from all the chief flax-growing districts of the country : the Kikuyu district, including Kabete, Kyambu, Limuru and Thika, and the districts of Nakuru, Lumbwa and the Uasin Gishu. Near Kericho, which is wetter and colder than Lumbwa, from farms up to within a distance of six miles from those of the Lumbwa area, which have suffered badly, caterpillars have been reported, but no serious damage has been done. Mr. T. J. Anderson, the Government Entomologist, has taken the moths of *Phytometra orichalcea* in the Trans-Nzoia district far from European cultivation.

The caterpillars have a wide range of food-plants. In East Africa they have been found to attack, in addition to flax, Canadian Wonder beans, potatoes, rape and other crucifers, as well as weeds.

The attack on the flax crop may take place at any stage, from the time the crop is only just above the ground up to the time of pulling. In its early stages the crop may be eaten up completely. In the later stages the seed-bolls are especially attacked. In a bad attack on the partly grown crop all the leaves and the tops of the stems are consumed, all that remains being the stripped stalks. When the caterpillars are less numerous a frequent form of damage is that the growing-point at the apex of the plant is killed and several weak secondary stems are thrown out. This results in shortening of the fibre and irregularity in the ripening of the seed.

The damage caused by flax caterpillars has been very serious, and many fields have been destroyed. There have been heavy losses in each of the three years 1918, 1919 and 1920, the worst reports having been received during the last year. Most of the damage is done from May to August, following the long rains, in the main growing season, but outbreaks have also occurred in the season following the short rains, which are due from October to December.

The life-history of *Phytometra orichalcea* was worked out in the laboratory at Kabete during the months of June to August, 1918, comparatively cool months. Eggs were deposited on the leaves or stems of the plants provided. The cocoons were spun on the host-plants, several leaves or stems being bound together. The caterpillars were fed on the weed *Galinosoga parviflora*. Little variation was found in the length of the life-cycle of different individuals. The average times for the different stages were :—

| | |
|---|---|
| Egg ... ... ... ... ... ... ... ... | 10 days. |
| Caterpillar (hatching to spinning cocoon) ... ... ... | 41 days. |
| Cocoon (spinning to emergence of moth) ... ... ... | 30 days. |

Eggs were laid a day or two after the emergence of the moths, making the length of the life-cycle, from egg to egg, about twelve weeks.

The caterpillar stage lasting, as it does, about six weeks, there is some little time for the detection of the pest while the caterpillars are still small. The large caterpillars are quite conspicuous, but the younger ones harmonise so well with their surroundings that unless a careful search be made they may easily be overlooked.

At least eight species of parasites, some Hymenopterous, some parasitic flies, have been reared from material from the field at Kabete.

Little success in controlling the caterpillars has been obtained by spraying. In May 1919 a number of spraying experiments were carried out in which strong Paris green did produce some results. The Paris green was used at the high rate of 3 lb. to 40 gallons. This was combined with (*a*) soap, (*b*) resin-washing-soda sticker, (*c*) lime, (*d*) lime and sticker. With these four plots were sprayed side by side, and subsequently some small dead caterpillars were found, the caterpillars in the field being mostly only about half-grown. Dead caterpillars could not be found on unsprayed control areas. About ten days after spraying there was a great difference between all these four plots and adjacent control areas. On the Paris green plots little damage could be seen as one looked across the field ; on the controls the caterpillars had retarded the growth considerably. A sharp line was seen between sprayed area and control. Later, the weather being damp, the control areas caught up with the sprayed parts of the field.

At other times spraying experiments with Paris green against larger caterpillars have not met with success. One planter, who did not supply full data, reported success with Paris green and lime, but the position is that one cannot recommend spraying to planters.

The method of combating the caterpillars by "roping" was devised by Mr. J. McDonald, a Lumbwa settler, whose description is now quoted :—

"A rope, 40 yards long and about one inch in diameter, held by a boy at each end, is dragged through the flax, the infested area being gone over from three to six times a day. If necessary more than one rope is kept in action at once. The rope should not be held too tightly. The boys use the same tracks each time and very little mechanical injury will have been done to the crop. The method is continued for several days, until the caterpillars have disappeared."

Here it is interesting to note, though the principle is not the same, that Dutt* in India, speaking of the caterpillars of *Phytometra orichalcea* in peas, says, "Dragging a rope, moistened with kerosine and turpentine, over the crop drives away the caterpillars. Even if they go into the neighbouring fields the crop is saved."

This roping method of Mr. McDonald's has been tried by quite a number of flax-growers. Their reports have varied. Some have said it was entirely successful, others that it was no use. Success, however, was reported in a sufficient number of cases to suggest that the method was of some value, and a week on farms in the Nakuru district, in June 1920, gave the opportunity of applying the tests to this method now described.

The method adopted was to obtain an index of the number of caterpillars in a flax field where roping was in progress and then, four days later, to obtain another index of the numbers present as a test of the result of roping. These numerical estimates were made by walking slowly through the flax and counting the number of caterpillars seen in five minutes, several such counts being made on each occasion. The counts were made by the same people each time, in the same part of the field, and at the same time of the day.

The results may be summarised as follows :—

*Field No. 1.*—The seed-bolls were just forming on the flax. Caterpillars were quite numerous. Just a very few had formed cocoons. After four days roping with heavy ropes about an inch in diameter the caterpillars were only a quarter as numerous as when the first count was made. There were a few more cocoons than previously,

* Report of the Proceedings of the Second Entomological Meeting, held at Pusa on the 5th and 12th February 1917.

but the increase in their numbers was entirely insufficient to account for the reduction in the numbers of caterpillars. Some may possibly have pupated in the ground (but compare with Field No. 2).

*Field No. 2.*—This field was on the same farm as No. 1 and quite near to it. The flax was nearly ready for pulling. The caterpillars, which were especially attacking the seed-bolls, were rather less numerous than in Field No. 1, but they were rather older and many cocoons had already been spun. The field was treated in the same way as the other, but after four days no reduction was found in the number of caterpillars.

*Field No. 3.*—In this field on a neighbouring farm the flax was in flower. The caterpillars were about as numerous as in Field No. 1. The field had been gone over about six times a day, but instead of rope, reim (twisted hide) had been used, the reim being much less heavy than the rope used on the first two fields. The reduction in the number of caterpillars was about 35 per cent., as against about 75 per cent. on Field No. 1.

*Field No. 4.*—As a check on the counts in the above three fields, counts were made on another field, which had not quite reached the flowering stage, where the caterpillars were not very plentiful. They were of fair size, but no cocoons were found. This field was not roped. The number of caterpillars found after the four days' interval was almost identical with that found previously.

*Field No. 5.*—On this field of flax in flower there was a very bad outbreak. Many of the caterpillars were in the last stage and cocoons were very plentiful. On part of this field the flax had been badly stripped of leaves before the outbreak was observed, and roping started, but caterpillars, while less numerous, were still present in large numbers in other parts of the field, and in these parts not many cocoons were seen. After four days of roping, with ropes about an inch in diameter, dragged through the flax half a dozen times a day, the caterpillars were appreciably fewer than previously on part of the field where the crop had not been seriously damaged, but the roping had not prevented the badly stripped area from increasing in size.

In the last field, some observations were made in order to try to determine just in what way the roping may bring about a reduction in the numbers of the caterpillars. Dead or injured caterpillars on the ground are not objects which readily catch the eye, but when a search was made some injured caterpillars were found. One large caterpillar which could just wriggle a little was found, and an hour later it was unable to move, being apparently dead. Another caterpillar, not very large, was found on the ground, moving only just a little; it did not make any attempt to climb up a flax plant; several small ants, one after the other, were seen to tackle it single-handed, when it would wriggle, and each time they gave up the attempt; but after an hour and a quarter it was attacked by these ants in force and carried off. Other caterpillars, some larger, some smaller, were seen to be attacked by ants successfully. In an area of two square feet where particular search was made, six victims of ants were found. One, which the ants had been watched carrying-off, was found an inch and a half below the surface of the soil. Another, injured at the hind end, succeeded at the third attempt in escaping from its assailants up a flax stem, which it climbed about three inches, but there it hung helpless from a leaf. It was found that a big healthy caterpillar was able to escape, even when placed in an ant-run, but half-grown healthy caterpillars were overwhelmed and carried off by a crowd of ants. Very small caterpillars were several times found being carried by only a single ant.

Obviously, from the fact that great numbers of caterpillars are seen climbing up the plants after being knocked off by the rope, the great majority escape after any one passage of the rope, but if only a small percentage be mortally injured, or placed at the mercy of ants, the cumulative effect would explain how the roping method acts. Six per cent. of casualties each time the rope passes, is sufficient to explain the figures recorded for Field No. 1.

Another explanation of the action of the roping method which has been put forward, is that the caterpillars, becoming weary of being repeatedly knocked off the plants, migrate from the field. A watch was kept for such migration from the field under discussion, but caterpillars were only found crawling out of the field where the flax had been stripped of leaves right up to the edge of the field. Where the flax offered plenty of food, the caterpillars remained there. It seems probable that the roping method, in so far as it does reduce the number of caterpillars, acts not by driving them out of the field, but by bringing about their death in the field.

The conditions involved in the success or failure of this method seem, therefore, to be :—

(1) Kind of rope and frequency of roping.
A heavy rope has more effect than a light one. The more times the field can be gone over in a day the better. If caterpillars are present in sufficient numbers to do appreciable damage, once or twice a day would do little good.

(2) Size of the caterpillars.
On small caterpillars the roping method has an effect both directly, by injury, and indirectly, by placing them at the mercy of ants. On large caterpillars there is little effect by either means.

(3) Numbers of the caterpillars.
Against an outbreak in which the caterpillars were very numerous, I doubt the efficacy of this method, unless, possibly, roping were done more times a day than would be feasible on a farm. Very little success has been reported against bad outbreaks, and in the light of the field observations just recorded this is not surprising. For,

(*a*) It appears that roping produces its effect by bringing about the death of only a small percentage of caterpillars each time the rope passes.

(*b*) Unless the numbers of ants or other predators attacking the caterpillars on the ground are increased by immigration, the larger the numbers of caterpillars, the less potent proportionately will the ants be to reduce the numbers of the caterpillars.

These facts, I believe, explain the different reports on the roping method—some of success, some of failure—which have come to hand. If the caterpillars are big before roping is started, if their numbers are very large, if the rope is too light, or if it is not passed through the field often enough, failure may be expected. But if the caterpillars are small and not present in excessive numbers, roping, properly carried out, will, I believe, meet the case.

It will thus be seen that there are distinct limitations to the roping method, and it is, moreover, a laborious one. Undoubtedly, it will be replaced by something more effective, and at present flax-growers are paying attention to various mechanical devices invented by several settlers for removing the caterpillars from the crop, while the search for other methods is being continued by the Division of Entomology.

# THE RED SCALE, CHRYSOMPHALUS AURANTII, MASK., IN KENYA COLONY.

By F. W. Dry, M.Sc.,
*Recently Assistant Government Entomologist, Kenya Colony.*

The first record of red scale in Kenya Colony in the file of the Entomological Laboratory is for 1914, on citrus. It is known that the scale has been brought into the country in at least one consignment of citrus, which, being accompanied by a certificate from the country of origin that the plants were free from insect pests, was allowed to enter the country under the Plant Import Regulations then in force, without being inspected. It seems, therefore, likely that red scale is not indigenous to the country, but an introduced pest.

In this belief, an attempt at eradication was made, in the hope that the insect might be prevented from becoming established in the country, and the citrus crop thus saved from a costly enemy. This attempt was also undertaken because of the possibility that red scale might attack coffee, a very much more important crop in the country than citrus. This was recognised as a danger for two reasons: first, because red scale in other countries has a very wide range of food-plants; and secondly, because quite a number of scales in Kenya Colony attack both citrus and coffee. These are: *Icerya purchasi*, Mask., *Saissetia hemisphaerica*, Targ., *Saissetia nigra*, Niet., *Coccus hesperidum*, L., *Ceroplastes ceriferus*, And., and *Selenaspidus articulatus*, Morgan.

Accordingly, the importation of citrus into the country was prohibited. At the same time, owners of citrus attacked by red scale were advised to destroy such trees, which were replaced free from the Government Farm, Kabete. Compulsory powers were not sought, but whenever planters were asked to destroy infected trees under this scheme, they consented to do so.

Commencing in 1917, inspections of citrus orchards and nurseries in search of red scale were made by the staff of the Division of Entomology and by the late Mr. J. J. Adams. A circular letter was sent out to citrus owners, accompanied by a specimen of red scale, asking them to make a search for the insect on their trees and to report the result. Sometimes it was found that other insects, such as *Coccus hesperidum* or *Selenaspidus articulatus*, or the citrus Psyllid, *Trioza* sp., were mistaken for red scale, so owners who reported the presence of this insect were asked to send a specimen from their trees.

By these means it was found that red scale was widely distributed in the country and that large numbers of trees were attacked. In some cases, citrus not being a profitable crop, little care has been taken of the trees and the scale has been allowed to multiply unchecked, so that in some neglected orchards great damage has been done by it.

In addition to citrus the plants now known to be hosts of red scale in this country are roses, apple, plum and sisal.

Fortunately, the fears that red scale might attack coffee have not so far been realised, and the following evidence, obtained both in the field and in the laboratory, is encouraging:—

(1) Red scale has never been observed or reported on coffee.

(2) A field of coffee, adjacent to some citrus trees, very badly infested with red scale, has been kept under observation. The citrus is very close to the outside row of coffee, the branches of the two often being in contact. All that has been found on the coffee, are objects that appeared to be red scale larvae, which have secreted the white covering just after settling (this the larvae have also done when put on coffee in the laboratory) and older individuals that were dead and had in all probability been washed off the citrus on to the coffee.

(3) In experiments in the laboratory many hundreds of red scale larvae have been placed on the leaves of coffee plants. Many of them secreted their white covering, but none made any further progress. Larvae similarly placed on citrus as controls lived and attained maturity and themselves produced offspring.

On the citrus plants, to which reference has been just made, the life-history of the red scale was worked out, the larvae having been placed on the plants in the middle of November 1917. The times when the various stages in the life-history were first reached were as follows :—

After the first day most of the larvae had secreted a covering.

After eight days the " pimple " was visible in the centre of the scale.

The first moult took place after 18 days.

The second moult of the female took place after 50 days.

The first male emerged on the 65th day.

The first larvae of the next generation were observed after 110 days.

The average daily temperatures during this life-cycle were : minimum, 54·5° F. ; maximum, 80·5° F.

Unfortunately the eradication of red scale has proved impracticable, but we may hope that coffee is immune.

Citrus is not at present an important crop in the country, though a great many people have a small number of trees. At local prices fumigation is impracticable, so that spraying is the control measure recommended.

The West Indian red scale, *Selenaspidus articulatus*, Morgan, has several times been mistaken for the common red scale by citrus owners. It occurs on both citrus and coffee, and has been found in widely separated parts of the country, but has not been known to do serious harm ; often only a single individual will be found on one leaf. In one citrus orchard in the Songhor district, a small number of trees could be described as badly infested. The fruit was attacked as well as the leaves, hundreds of individuals being found on a single orange, which was thus rendered quite unsightly.

A citrus plant was infected in the laboratory, at the same time as those on which the red scale life-history was worked out. Larvae of the next generation were first observed after 120 days.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. Ballard, Government Entomologist :—3 Tachinidae, 30 Coleoptera, 100 Thysanoptera, 60 Rhynchota, and a collection of Nematode worms suspected of damaging crops ; from Madras.

Mr. G. E. Bodkin, Government Economic Biologist :—35 Culicidae, 5 Tabanidae, 15 other Diptera, 14 Hymenoptera, 141 Coleoptera, 6 Moths, 50 Isoptera, 2 species of Coccidae, 41 other Rhynchota, 2 Orthoptera, 5 Odonata, 44 Spiders, 4 Scorpions, 2 Centipedes, 5 Millipedes, 2 Worms, and 10 insects attacked by Entomogenous fungi ; from British Guiana.

Mr. Harold E. Box :—8 Tabanidae, 13 other Diptera, and 4 species of Coccidae ; from Argentina.

Mr. P. A. Buxton :—30 Rhynchota ; from Mesopotamia.

Dr. G. D. H. Carpenter :—10 Tabanidae, 5 other Diptera, 9 Hymenoptera, 198 Coleoptera, 34 Rhynchota, 26 Orthoptera, and 2 Stone-flies ; from Uganda.

Mr. J. B. Corporaal, Entomologist, Algemeen Proefstation, Medan :—8 Curculionidae and 23 Rhynchota ; from Sumatra.

Mr. M. T. Dawe :—1 *Tabanus*, 15 *Glossina*, 60 Coleoptera, 9 Lepidoptera, and 1 species of Coccidae ; from Gambia ; and 8 Tabanidae and 111 Ticks ; from Colombia.

Mr. D. d'Emmerez de Charmoy :—1 Tube of Cecidomyiidae, 6 Lepidoptera, 1 species of Coccidae, and 300 Aphididae ; from Mauritius.

Dr. Eustace W. Ferguson :—37 Tabanidae ; from Australia.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—30 Anoplura ; from India.

Mr. C. C. Gowdey, Government Entomologist :—220 Ants, 32 Chalcids, 3 other Hymenoptera, 10 Coleoptera, 7 Lepidoptera, 50 Thysanoptera, 7 species of Coccidae, 3 other Rhynchota, 1 Dragon-fly, and 45 Mites ; from Jamaica.

Mr. E. Hargreaves :—70 Sheep "Ticks," 13 Lepidoptera, and 2 Orthoptera ; from the United Kingdom : and 2 Mutillidae, 115 Coleoptera, and 5 Rhynchota ; from North America.

Mr. H. Hargreaves, Government Entomologist :—10 Hymenoptera, 123 Coleoptera, and 49 Rhynchota ; from Uganda.

Mr. G. F. Hill, Entomologist, Australian Institute of Tropical Medicine :—191 Culicidae, 59 Tabanidae, 57 other Diptera, 6 Ants, 5 Chalcids, 16 Coleoptera, 12 Isoptera, 5 species of Coccidae, and 4 other Rhynchota ; from Australia.

Dr. Walther Horn :—4 specimens of *Chrysops costata*, F. ; from Cuba.

Mr. M. Afzal Husain, Government Entomologist :—54 Diptera and 33 Chalcids ; from the Punjab.

Mr. J. C. Hutson, Government Entomologist :—387 Parasitic Hymenoptera, 39 Ticks, and 6 other Arachnida ; from Ceylon.

Mr. F. P. Jepson, Assistant Government Entomologist :—38 Coleoptera ; from Ceylon.

Mr. L. Lewton-Brain, Director of Agriculture :—5 Diptera, 91 Coleoptera, 24 Lepidoptera, and 14 Orthoptera ; from the Federated Malay States.

Major W. F. M. Loughnan, R.A.M.C. : 4 Tubes of Ceratopogoninae ; from Jamaica and British Honduras.

Mesopotamia, Director of Agriculture :—40 Diptera, 13 Hymenoptera, 37 Coleoptera, 28 Lepidoptera, and 46 Rhynchota ; from Mesopotamia.

Mr. F. Muir :—14 Homoptera ; from Samoa, etc.

Mr. H. K. Munro :—18 Coleoptera ; from South Africa.

Prof. G. H. F. Nuttall, F.R.S. :—2 Tabanidae, 22 *Stomoxys*, 2 Hippoboscidae, and 108 other Diptera ; from Mesopotamia.

The Rev. Father J. A. O'Neil, S.J. :—87 Coleoptera and 7 Moths ; from Southern Rhodesia.

Dr. L. Péringuey, Director of the S. African Museum :—4 Weevils ; from Cape Colony.

Philippine Islands, Director of Agriculture :—8 Orthoptera ; from the Philippines.

Mr. A. W. J. Pomeroy, Government Entomologist :—14 Diptera, 400 Chalcids, 30 other Hymenoptera, and 28 Lepidoptera ; from Nigeria.

Pretoria, Division of Entomology :—84 Orthoptera ; from South Africa.

Mr. A. H. Ritchie :—100 Ants, 3 Chalcids, 152 Coleoptera, 13 species of Coccidae, and 200 Aphididae ; from Jamaica.

Senhor A. F. de Seabra :—18 Orthoptera and 2 Odonata ; from San Thomé.

Dr. B. P. Uvarov :—28 Hymenoptera, 34 Coleoptera, and 4 Rhynchota ; from Transcaucasia.

Mr. Robert Veitch :—29 Diptera, 12 Chalcids, 16 other Hymenoptera, 118 Coleoptera, 50 Lepidoptera, and 30 Rhynchota ; from Fiji.

Sir Francis Watts, K.C.M.G., Imperial Commissioner of Agriculture :—400 Chalcids, 50 Coleoptera, 37 Lepidoptera, 4 species of Coccidae, Aleurodidae and Aphididae, and 2 other Rhynchota ; from the British West Indies.

Wellcome Bureau of Scientific Research :—26 Meloid beetles ; from Peru.

Mr. C. B. Williams :—4 Coleoptera and 13 Rhynchota ; from Trinidad.

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